Geotechnical Report
Downtown Pedestrian/
Bremerton Transportation Center
Access Improvements
Bremerton, Washington

July 21, 2006

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

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July 21, 2006

Mr. Gary Demich
Exeltech Consulting, Inc.
2590 Willamette Drive NE
Lacey, WA 98516

RE: REVISED GEOTECHNICAL REPORT, DOWNTOWN PEDESTRIAN/ BREMERTON TRANSPORTATION CENTER ACCESS IMPROVEMENTS, BREMERTON, WASHINGTON

Dear Mr. Demich:

We are pleased to provide you with our geotechnical report for the Bremerton Access Improvements project. This revised report includes the results of our recent groundwater testing, additional subsurface explorations, and responses to comments received from the Washington State Department of Transportation (WSDOT) Geotechnical Division based on their review of the November 1, 2005, geotechnical report.

I am available at (206) 695-6875 if you have any questions.

Sincerely,

SHANNON & WILSON, INC.

Martin Page

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Associate

MWP/mwp

Enclosure: Geotechnical Report

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GEOTECHNICAL REPORT
DOWNTOWN PEDESTRIAN/BREMERTON TRANSPORTATION CENTER ACCESS IMPROVEMENTS
BREMERTON, WASHINGTON

1.0 INTRODUCTION

This report describes subsurface conditions and provides geotechnical engineering recommendations for the Downtown Pedestrian/Bremerton Transportation Center Access Improvements (DP/BTC) project. The DP/BTC alignment is located in downtown Bremerton, between the Bremerton Transportation Center (Washington State Ferries [WSF] terminal) and the intersection of Burwell Street and Naval Avenue. The proposed DP/BTC project will include access improvements to and from the BTC. Ferry traffic ingress would continue to be supported via the Burwell Street-Pacific Avenue-1st Street route currently in use. Primary ferry traffic egress, currently via Washington Avenue, would shift to the same alignment as the ingress traffic. Secondary vehicular access to Washington Avenue would be provided. A tunnel alternative has been selected to route traffic from BTC to Burwell Street.

The tunnel will provide a two-lane, one-direction roadway for ferry traffic egress. The project will also involve reconfiguring and reconstructing the surface alignment of Burwell Street (between Warren Avenue and Pacific Avenue), Pacific Avenue (between 1st Street and Burwell Street), and 1st Street to accommodate ferry traffic ingress. Between Warren Avenue and Pacific Avenue, Burwell Street would be four lanes – two lanes eastbound and two lanes westbound.

The tunnel alternative also includes realignment of the 1st Street and Pacific Avenue Puget Sound Naval Shipyard (PSNS) gate approach to accommodate the proposed Kitsap Transit and WSF improvements to the BTC that include:

- Providing holding space for approximately 200 cars.
- Adding three realigned WSF tollbooths, at least two with adjacent 80-foot-long truck holding areas, and building a new 1,000- to 1,200-square-foot WSF office building.

The purpose of this geotechnical report is to provide the Washington State Department of Transportation (WSDOT) and the design team with the geotechnical data and recommendations needed for design of the proposed tunnel and related improvements. General recommendations are provided in this report for planning and preliminary design of temporary shoring walls. We understand that shoring will be designed by the project Contractor, thus our recommendations are preliminary and should be evaluated by the Contractor's design team. Our scope of services included characterization of the subsurface conditions based on literature review, subsurface explorations, and laboratory testing. We have developed subsurface profiles, performed geotechnical engineering analyses, and prepared the conclusions and recommendations presented herein.

2.0 SITE DESCRIPTION

The Vicinity Map, Figure 1, shows the project location in downtown Bremerton. The project site consists of approximately 2,500 lineal feet of paved roadways with commercial developments on nearly all sides. There is a large, concrete retaining wall at the northeast corner of the PSNS that borders the project alignment at the intersection of Burwell Street and Pacific Avenue. This wall is approximately 743 feet long and rises up to 26 feet above the ground surface of the PSNS yard; i.e., the wall extends 26 feet below street level. A portion of this wall will be removed to facilitate construction of the tunnel.

The topography of the project alignment generally slopes down gently (14 percent) from north to south along the Pacific Avenue portion. The Burwell Street portion slopes down gently from Pacific Avenue for a distance of approximately 700 feet and then slopes up as it extends toward Warren Avenue. The ground surface elevation is highest at the intersection of Pacific Avenue and Burwell Street (approximate elevation 47 feet) and lowest at the ferry terminal (approximate elevation 25 feet).

3.0 EXPLORATIONS AND TESTING

3.1 Previous Subsurface Data

As part of our work, we collected and reviewed previous subsurface explorations performed by others for past projects in the vicinity of the DP/BTC alignment. These previous explorations are associated with studies done for PSNS projects in 1983, Bremerton wastewater improvements in 1988, and a WSDOT study done in 2002. The borings were performed by various individuals using different drilling and sampling methods. Because of this, the quality of information presented on the boring logs by other firms may not be consistent with current standards. The locations of previous borings reviewed for the current study are shown on the Site and Exploration Plan (Figure 2), and the logs are included in Appendix A, Subsurface Explorations.

3.2 Current Explorations

A subsurface exploration program was performed along the project corridor to supplement the existing subsurface information. Nine soil borings were performed in 2004 and 10 additional borings were performed in July 2006 in areas where existing information either was not present or was inadequate, and in areas where structures may be located. These borings were extended to depths of 45 to 70 feet, and groundwater monitoring wells were installed in boreholes SW-1 through SW-8. Locations of the borings are shown in the Site and Exploration Plan, Figure 2.

The field exploration methodology and procedures used during drilling and sampling are discussed in Appendix A. The exploration logs are also presented in Appendix A. A Soil Classification and Log Key is provided as Figure A-1 to aid in understanding the information presented in the boring logs.

3.3 Geotechnical Laboratory Testing

To aid in our engineering analyses, laboratory tests were performed on selected samples retrieved from the project borings to determine basic index properties of the soils encountered and to aid in their classification. The geotechnical testing was performed in our Seattle laboratory and included visual classification, water content determinations, Atterberg limit determinations, and grain size distributions. Descriptions of the test procedures and summaries of the test results are presented in Appendix B, Geotechnical Laboratory Testing Procedures and Results.

3.4 Analytical Testing

During drilling in 2004 for the current exploration program, the soils were screened using olfactory methods (odors) and a photoionization detector (PID) to assess the potential for hydrocarbon contamination. Two samples from the upper 5 feet of two soil borings (S-1 and S-2 of boring SW-3, and S-1 and S-2 of boring SW-4) were suspected of containing hydrocarbons based on field or laboratory screening results. These samples were collected in plastic jars and returned to our Seattle laboratory. They were transported to OnSite Environmental, Inc. (OSE) of Redmond, Washington, for chemical identification analysis. Samples of groundwater from monitoring wells SW-3 and SW-4 were subsequently collected and tested at OSE. A discussion of the analytical results and copies of the analytical reports are presented in Appendix C.

We also detected hydrocarbon-impacted soils in borings SW-10, SW-11, SW-12, SW-13, and SW-14. No analytical testing was accomplished on samples from these borings. Additional sampling for laboratory analyses will occur during a geoprobe investigation to be conducted under a separate scope of services. The results will be presented in a separate report.

4.0 SUBSURFACE CONDITIONS AND CHARACTERIZATION

The City of Bremerton is located in the central portion of the Puget Sound Lowland, an elongated topographic and structural depression bordered by the Cascade Mountains to the east and the Olympic Mountains to the west. The structural depression that forms the Lowland consists of a north-trending series of 20- to 30-kilometer (km)-wide basins and uplifts of Tertiary volcanic and sedimentary rocks. The Lowland is filled with glacial and interglacial Quaternary sediments of varying thicknesses that generally unconformably overlie the Tertiary bedrock. A geologic map of the project area is presented in Figure 3.

Six or more major glaciations during the Pleistocene Epoch (2 million years ago to about 10,000 years ago) have resulted in a complex distribution of sediments in the Puget Sound Lowland. The glacial ice for these glaciations originated in the coastal mountains of Canada and generally flowed southward into the Puget Sound region. The maximum southward advance of the ice was about halfway between Olympia and Centralia (about 50 miles south of Bremerton). Each glacial advance scoured exposures of bedrock which partially eroded, previously deposited sediments, and deposited new sediments. During the intervening interglacial episodes, the complete or partial erosion or the reworking of some deposits, as well as the local deposition of other sediments, further complicated the geologic setting. The ice sheet of each glaciation overrode and compacted underlying soils to a very dense or hard (overconsolidated) condition.

During the most recent ice coverage of the central Puget Sound Lowland (Vashon Stade of the Fraser Glaciation), the thickness of ice is estimated to have been about 900 meters in the project area. The last ice covering the project area receded about 13,500 years ago. The soil units associated with the Vashon Stade consist of a lacustrine deposit, advance outwash, till, and recessional outwash. All units of the Vashon Stade and the underlying pre-Vashon units, except for the Vashon recessional outwash, are glacially overridden and overconsolidated.

Following the recession of the glacial ice from the Lowland, the ground rebounded and the sea level rose. Rebound ceased about 9,000 years ago, but sea level continued to rise until about 5,000 years ago. Post-glacial erosion and alluvial processes in some areas have removed and reworked some glacial deposits and deposited additional normally consolidated and unconsolidated soils over the dense glacial material. Slope movements, reworking of deposits by humans, and artificial filling have also contributed to deposition of sediments over the glacially derived soils.

At the DP/BTC project site, a layer of fill material overlies native soils consisting of dense to very dense sands and gravels. These native soils appear to be older, undifferentiated outwash sediments. They consist of sands and gravels that are generally dense to very dense, indicating that they have been overridden by glacial ice.

4.1 Tectonics and Seismicity

The project area is located in a region where numerous small to moderate earthquakes and occasional strong shocks have occurred in recorded history of the region. Much of this seismicity is the result of ongoing relative movement and collision between the tectonic plates that underlie North America and the Pacific Ocean. In the Pacific Northwest, these tectonic plates include the Juan de Fuca Plate and the North American Plate, and the intersection of these two plates is called the Cascadia Subduction Zone (CSZ). As these two plates collide, the Juan de Fuca Plate is being driven northeast, beneath the North American Plate. The action of one plate being driven below another is called subduction. The relative movements of these plates are schematically shown in Figure 4.

The relative plate movements beneath the Pacific Ocean and the west coast of North America not only result in east-west compression, but also result in shearing, clockwise rotation, and north-south compression of the crustal blocks that form the leading edge of the North American Plate (Wells et al., 1998). It is estimated that the north-south compression rate for the blocks beneath western Oregon and Washington is about 4 to 9 millimeters (mm) per year, and much of the compression may be occurring within the more fractured, northern Washington block that underlies the Puget Sound Lowland.

Within the present understanding of the regional tectonic framework and observed seismicity, three broad earthquake source zones are identified that may pose significant ground motion hazard to the Puget Sound Lowland. These include a shallow crustal source zone, a deep source zone within the portion of the Juan de Fuca Plate subducted beneath the North American Plate (deep subcrustal zone), and an interplate zone where the Juan de Fuca and North American Plates are in contact in the CSZ. Historical seismicity has been observed in both the shallow crustal zone and the deep subcrustal zone. Geologic evidence and written records outside the Pacific Northwest indicate that the interplate zone is also active and generates large earthquakes. The following provides a brief description of each of these source zones.

4.2 Site Geology

In general, the subsurface conditions in the vicinity of the project site consist of loose to dense fill materials overlying competent outwash soils derived from the Vashon Stade of the Fraser Glaciation. A geologic map of the surface geology (which does not include fill that is less than about 20 feet thick) confirms these findings, as the surface geology in the immediate area is identified as Fraser-age, undifferentiated outwash (Dragovich et al., 2002).

Exploratory borings encountered approximately 2 to 20 feet of fill material that generally included slightly fine gravelly, slightly silty to silty, fine to medium sand and fine sandy silt. A generalized subsurface profile based on soil borings performed by Shannon & Wilson, Inc. and others is presented in Figure 5. As shown in Figure 5, the fill material is estimated to be 2 to 12 feet thick for the majority of the subsurface profile, from the southern terminus of the tunnel to boring SW-5 (between Stations 14+50 and 24+00). Borings SW-1, SW-11, SW-12, SW-14, B-19, B-20, and B-21 indicate the presence of very dense glacial outwash soils very near the surface.

The thickness of fill material in the vicinity and west of boring SW-6 (between Stations 8+00 and 14+00) is estimated to range from 4 to 20 feet. The greater depth to glacial soils in this area can perhaps be explained by the presence of a retaining wall adjacent to the south side of Burwell Street (approximately 50 feet south of SW-6). This wall is between 15 and 25 feet high, and its top elevation is approximately level with Burwell Street. The excavation activities associated with the construction of this wall likely required sloping of the native soils north of the wall and subsequent backfilling.

A thick deposit of undifferentiated glacial outwash (Qgo) was encountered directly beneath the fill material, and generally included dense to very dense, clean to silty, slightly fine gravelly to fine gravelly sand with scattered layers of slightly silty to silty, sandy gravel. The glacial outwash in the vicinity and west of boring SW-6 (between Stations 8+00 and 14+00) is better described as dense to very dense, slightly silty to silty, fine to medium sand. A glaciolacustrine deposit, consisting of hard, silty clay to clayey silt (Qvgl), was encountered underlying the glacial outwash at a depth of approximately 53 feet below ground surface (borings SW-1, SW-11, SW-12, and SW-13). These fine-grained soils are approximately 15 to 20 feet deeper than the proposed excavation limits of the tunnel alternative.

4.3 Groundwater Occurrence

Identifying the depth of the static groundwater table is important for temporary shoring of excavations and design of the permanent tunnel structure. Therefore, monitoring wells were installed in each of the soil borings performed by our firm (SW-1 through SW-8) in 2004. The depth to groundwater is variable across the project site, i.e., from 16.7 to 37.7 feet. However, as shown in Figure 3, the water table elevation is relatively consistent along most of the proposed project alignment, indicating little horizontal gradient. Based on measurements conducted at various times of day, the water table does not appear to be significantly influenced by tidal fluctuations. Table 1 shows the depth to groundwater at each of the boring/monitoring well locations over a 2-year period. Refer to the Site and Exploration Plan in Figure 2 for the locations of the borings.

5.0 GEOTECHNICAL RECOMMENDATIONS

5.1 Earthquake Engineering

For surface structures, the appropriate site response spectra are based on the soil site class. While the tunnel alternative is not a surface structure, we determined the soil site classes along the alignment to assist with the general characterization of the subsurface conditions, and to confirm that the soil units adjacent to the tunnel structure are sufficiently stiff so that no site-specific ground response analyses are required. Based on mean penetration resistance values in the upper 100 feet obtained from the Standard Penetration Test (SPT), the soils along the tunnel alignment may be classified as Site Class C because of the predominance of the glacially overconsolidated sand and gravel soils encountered near the ground surface.

TABLE 1
DOWNTOWN PEDESTRIAN/BREMERTON TRANSPORTATION CENTER ACCESS IMPROVEMENTS—MONITORING WELL READINGS

Boring	SW-1		SW-2		SW-3		SW-4		SW-5		SW-6		SW-7		SW-8	
Water Level (feet)	Bgs	Elev.	Bgs	Elev.	Bgs	Elev.	Bgs	Elev.	Bgs	Elev.	Bgs	Elev.	Bgs	Elev.	Bgs	Elev.
Date																
3/2/2004	21.7	7.1	16.6	5.7					37.5	6.8	29.7	6.8				
3/4/2004			16.6	5.7	24.5	9.1			37.6	6.7	29.8	6.7				
3/5/2004	22.0	6.8														
3/18/2004	21.8	7.0	16.8	5.6	24.5	9.2	32.6	6.4	37.7	6.6	30.0	6.6				
3/31/2004			16.4	5.9	23.8	9.8	32.3	6.7	37.3	7.0	32.5	4.0				
4/23/2004	21.5	7.3	16.6	5.7	23.7	9.9	32.5	6.5	37.5	6.8	29.8	6.7				
7/12/2004	21.9	6.9	16.6	5.7	23.7	9.9	32.9	6.1	37.9	6.4	30.2	6.3				
2/14/2006	22.0	6.8	16.6	5.7	25.0	8.6	32.4	6.6	37.6	6.7	29.7	6.8	22.3	6.7	14.6	8.4
2/15/2006					25.0	8.6										
2/16/2006	21.4	7.4	16.5	5.8	24.9	8.7	32.4	6.6	37.6	6.7	29.7	6.8	22.3	6.7		

Note:
bgs = below ground surface.
Elevations are in Feet

5.1.1 Ground Motions

We understand that earthquake design for the tunnel will be in accordance with design levels for highway bridges in specifications by the American Association of State Highway and Transportation (AASHTO). Earthquake design using the current AASHTO specifications (2005 AASHTO Load Resistance Factor Design [LRFD] Bridge Design Specifications) require that the design be based on ground motions with a return period of at least 475 years. Recent regional probabilistic ground motion hazard studies by the U.S. Geological Survey (Frankel et al., 2002) indicate that earthquake ground motions with a 475-year return period for rock site conditions are characterized by a peak ground acceleration (PGA) of 0.35g. Consequently, we recommend that a site PGA of 0.35g or an Acceleration Coefficient (A) of 0.35 be used in the seismic analyses. The corresponding Seismic Performance Zone in the 2004 LRFD specifications is 4. We note that the recurrence rate for large earthquakes in the Seattle Fault Zone (SFZ), in which the project is located, is much longer than the 475-year return period required for seismic design; therefore, the ground motions at the site for a large earthquake on the SFZ are greater than 0.35g required for design.

Based on the subsurface conditions encountered in the subsurface explorations, we recommend that the site be classified as AASHTO Soil Profile Type II with a corresponding Site Coefficient (S) of 1.2. AASHTO describes a Soil Profile Type II as a very stiff cohesive or dense cohesionless soil profile over 200 feet thick.

5.1.2 Earthquake-induced Geologic Hazards

Earthquake-induced geologic hazards that may affect a given site include liquefaction and associated effects (such as loss of shear strength, bearing capacity failures, loss of lateral support, ground oscillation, and lateral spreading), settlement, landsliding, and ground surface fault rupture. The potential for each of these hazards at the site was evaluated and was found to be low.

Liquefaction may occur in loose, saturated, cohesionless soils subjected to earthquake ground motions. The dense nature of most of the site soils precludes liquefaction and associated effects (such as, loss of shear strength, bearing capacity failures, loss of lateral support, ground oscillation, and lateral spreading). Similarly, the relatively dense nature of the foundation soils precludes the occurrence of significant earthquake-induced differential settlement.

Areas that pose a significant landslide hazard under seismic conditions often pose a hazard under static conditions (e.g., slopes that are marginal or unstable under static conditions generally pose a landslide hazard under earthquake conditions). Because of the relatively flat topography at the site and the relatively dense/hard nature of the site soils, the risk of landsliding is very low.

The potential for ground surface fault rupture is also low. As previously indicated, the project area lies within the SFZ, with mapped fault traces located within 1,000 feet north and south of the site. However, the recurrence interval for large earthquakes capable of rupturing the ground surface in this zone appears to be on the order of thousands of years (Nelson et al., 2003a, 2003b), much longer than the 475-year return period specified for seismic design by AASHTO. Therefore, the ground surface fault rupture hazard at the site is low under the specified design earthquake.

5.1.3 Seismic Design Parameters

We understand that the displacement analysis will be used to design the tunnel for seismic loading. Based on subsurface conditions encountered in soil borings at the site, we have developed the following recommended seismic design parameters.

TABLE 2
SEISMIC DESIGN PARAMETERS

Peak Ground Acceleration in Soil (g)	Peak Ground Velocity (fps)	Effective Shear Wave Velocity (fps)	Average Strain-Compatible Shear Modulus (ksf)	Free-field Strains [1] (%)
0.39	1.4	1,200 – 2,000	4,500	0.12 – 0.07

Notes:
[1] Free-field strains caused by vertically propagating shear waves of the design earthquake.
fps = feet per second
ksf = kips per square foot

5.2 Excavations

5.2.1 General

Excavations can be accomplished with conventional earthwork equipment such as dozers, loaders, and track-mounted excavators. Ripping may facilitate excavations in the very dense, glacially consolidated soils. Temporary excavation slope angles should be the responsibility of the Contractor; however, for planning purposes, our recommended temporary excavation slope angles are presented in the following section. All applicable safety standards pertaining to excavation slopes and shoring should be followed.

5.2.2 Anticipated Soil Behavior

The anticipated behavior of the soils expected in the tunnel excavation is based primarily on the assessment of ground conditions derived from available exploration data and practical experience in the Puget Sound area. Actual ground behavior will be a function of several factors including: (a) the actual soil and groundwater conditions as exposed in the excavations, (b) excavation and initial support methods, (c) timing and sequence of excavation and support, and (d) workmanship.

The behavior of the fill deposits is difficult to predict because of the variable composition and strength of these materials. However, the fill was typically classified as loose to very dense, and may have poor standup time where loose zones are present. Deleterious material, such as ash, concrete, brick, wood debris, organics, and other debris should be expected in the fill. For planning purposes, we recommend that temporary excavation slopes in the fill be cut at 1.5 Horizontal to 1 Vertical (1.5H:1V). Steeper or flatter slopes may be necessary depending on local conditions observed during construction.

The glacial outwash deposits (Qgo) are composed primarily of dense to very dense, sandy gravel and silty to clean, fine gravelly sand. Their very dense, granular consistency makes them relatively easy to excavate with conventional soil excavation equipment such as track-hoes and backhoes. Their in-place strength properties promote good standup time with relatively steep excavation slopes for 3- to 4-foot-high vertical cuts for shoring installation. For planning purposes, we recommend temporary slopes of 1H:1V in glacial outwash soils.

5.2.3 Groundwater Control

Based on the results of the borings drilled along the proposed tunnel alignment, groundwater control will be required during construction of the tunnel alternative. Dewatering should be provided as necessary to maintain the groundwater level at least 2 feet below the bottom of the excavation. All formwork, fill placement, compaction, and concrete placement should be accomplished in the dry, dewatered excavation. Hydrostatic pressures should not be allowed to build up behind temporary shoring walls.

We have performed limited groundwater dewatering studies and field "slug tests" to identify aquifer flow parameters that may be used for preliminary dewatering system design and to size the pumps for the emergency sump pumps. The tunnel will be constructed with a dual pump chambers that discharge directly to the new Combined Sewer Overflow (CSO) line to be constructed adjacent to the tunnel. While leaks in the tunnel are unlikely, one of the purposes of this analysis was to provide estimates of long-term groundwater inflow rates in the event of a leak. For purposes of modeling groundwater flow rates, we have assumed that the tunnel would develop a single leak in the invert slab.

To develop an estimate of the potential long-term groundwater flow rate into the tunnel, our scope of services included the following hydrogeologic tasks:

- Collected groundwater measurements at observation wells SW-1 through SW-8.
- Developed the saturated screen sections of two observation wells located adjacent to the proposed tunnel alignment (SW-2 and SW-3).
- Sampled and drummed the purged groundwater from SW-2 and SW-3.
- Transported the drummed groundwater to the City of Bremerton Public Works Department yard for temporary storage.
- Arranged for disposal of the drummed groundwater following receipt of groundwater quality results.
- Performed in situ hydraulic conductivity testing (slug tests) at SW-2 and SW-3.
- Developed estimates of the anticipated long-term flow rates to using an analytical groundwater model.
- Prepared this summary of our field activities and analyses.

We measured groundwater levels at eight observation wells previously installed for this project on February 14, 2006. Groundwater levels at the seven wells located closest to the proposed tunnel were measured again on February 16, 2006, after development of wells SW-2 and SW-3 was completed. These groundwater elevation data are presented in Table 1.

5.2.3.1 Well Development

Observation wells SW-2 and SW-3 were developed on February 14 and 15, 2006, respectively, to improve the hydraulic connection between the well screens and the surrounding aquifer soils. Groundwater was extracted from the wells using a combination check valve/surge block, with each screen being surged and pumped from the top of the water column to the bottom of the well. During development, approximately 40 and 42 gallons of water were removed from SW-2 and SW-3, respectively. The extracted groundwater was drummed, and the labeled drums were transported to the City of Bremerton Public Works yard for temporary storage. At the end of development, each well was sampled for petroleum hydrocarbons in order to facilitate selection of an appropriate disposal option for the drummed water. The samples were delivered under chain-of-custody to On-Site Environmental Inc. of Redmond, Washington. The samples were tested by method Northwest Total Petroleum Hydrocarbons – Hydrocarbon Identification (NWTPH-HCID); petroleum hydrocarbons were not detected in either sample (Table C-3 in Appendix C). The laboratory data report attached in Appendix C. On March 10, 2006, Emerald Services collected the drummed water for disposal, along with soil cuttings generated in 2004 during the drilling of previous borings SW-7, -8, and -9. The bill of lading and volume ticket for these drums is included in Appendix C.

5.2.3.2 Slug Testing

Slug tests were performed in wells SW-2 and SW-3 to estimate representative values of aquifer hydraulic conductivity. These wells are screened across the water table in the glacial outwash deposits (Qgo) near the proposed base of the tunnel.

The slug tests were performed on February 16, 2006. Water levels during the testing periods were recorded at each location using a downhole data logger/transducer (In-Situ Minitroll™), which was installed at the bottom of the well; backup manual measurements were also collected during the tests using an electronic water level indicator. A slug was used to induce a change in the water level in each well; the slug consisted of a sealed, sand-filled, 1.25-inch-diameter, 7-foot-long, polyvinyl chloride (PVC) pipe, suspended on a nylon line from an eye bolt.

A water-level indicator was used to measure the static water level prior to the start of the first test at each well. Water-level measurements were collected on one-second intervals during the slug tests. Multiple slug tests were performed at each well. Preparation for each test consisted of placing the slug into the water column of the well and allowing the water level to equilibrate back to its static level. Then the test was initiated by rapidly removing the slug from the well (rising-head test). Upon completion of the tests, the data were reduced into spreadsheet format and graphed for analysis.

5.2.3.3 Slug Test Results

The slug test analytical solution developed by Bouwer and Rice (1976) and later modified by Bouwer (1989) was used in evaluating the slug test data. The Bouwer and Rice solution was developed for determination of horizontal hydraulic conductivity at fully or partially penetrating wells screened in unconfined aquifers. For each slug test, the log of the change in water level within the well casing was plotted against the time since the start of the test; the slope of the line is used in the Bouwer and Rice calculation of hydraulic conductivity. The semi-log plots of water level change versus time for the slug tests performed at each well are presented as Figures 9 and 10.

The range of calculated values of hydraulic conductivity are presented for each well in Table 3. In general, the slug test hydraulic conductivity values for the Qgo soil ranged between 1 x 10-2 and 5 x 10-2 centimeters per second (cm/sec). The influence of a slug test extends only a short distance into the soils surrounding a well screen, and the area tested is relatively small compared with that influenced by a pumping test. Therefore, aquifer parameters estimated by slug testing are representative only of the saturated soils in the immediate vicinity of the screen; the actual hydraulic conductivity of the Qgo soil may vary along the alignment of the proposed tunnel.

TABLE 3
SLUG TEST RESULTS

Observation Well Designation	Date Tested	Slug Test Type and Number	Static Groundwater Depth (feet below grade)	Hydraulic Conductivity (feet/minute)	Hydraulic Conductivity (feet/day)	Hydraulic Conductivity (centimeters/second)
SW-2	2/16/2006	Rising Head Test 1	16.5	1.6E-01	227.5	**8.0E-02**
SW-2	2/16/2006	Rising Head Test 2	16.5	8.5E-02	123.1	**4.3E-02**
SW-2	2/16/2006	Rising Head Test 3	16.5	9.4E-02	134.9	**4.8E-02**
SW-2	2/16/2006	Rising Head Test 4	16.5	8.9E-02	127.8	**4.5E-02**
Probable Formation GEOMEAN, Last 3 Tests				8.9E-02	128.5	**4.5E-02**
SW-3	2/16/2006	Rising Head Test 1	24.9	3.6E-02	51.1	**1.8E-02**
SW-3	2/16/2006	Rising Head Test 2	24.9	3.6E-02	52.0	**1.8E-02**
SW-3	2/16/2006	Rising Head Test 3	24.9	3.9E-02	56.9	**2.0E-02**
SW-3	2/16/2006	Rising Head Test 4	24.9	4.1E-02	59.5	**2.1E-02**
Probable Formation GEOMEAN, All 4 Tests				3.8E-02	54.8	**1.9E-02**

5.2.3.4 Leak Inflow Analysis And Recommendations

Using the results of the slug tests at SW-2 and SW-3, we estimated the long-term inflow through a potential leak in the tunnel invert using an analytical solution for flow to a drainage trench from a line source, as described by Powers (1992). We also estimated the long-term inflow using a well field model based on the Theis (1935) solution for radial flow to a well. We used a range of groundwater levels, including the highest measured at the project observation wells and a potential groundwater level about 2 feet above the highest recorded levels to account for seasonal variations and for potential changes in the groundwater flow regime that may result from construction of this project. Values of hydraulic conductivity used in the inflow analyses ranged from 5×10^{-2} to 9×10^{-2} cm/sec. The aquifer base elevation was estimated to be between about elevation -14 and -19 feet; however, the base of the effective contributing zone may vary considerably from these values. Based on our analyses, inflow rates from a discrete leak point in the tunnel invert may range from 50 and 100 gallons per minute. Therefore, we recommend that the emergency sump pump in the tunnel invert be sized to accommodate this level of flow.

5.3 Temporary Excavation Support

5.3.1 General

Based on the proximity of adjacent building foundations, the street decking requirements during construction, and right-of-way issues, we anticipate that an excavation support system (shoring) will be required along the east side of the tunnel excavation. Open-cut excavations with stable side slopes are anticipated along the west side of the alignment where space permits. Shoring adjacent to existing structures may consist of soil nail walls or soldier piles with timber lagging supported by internal bracing and/or tieback anchors. Internal braces will extend across the excavation or can be installed as rakers within the excavation.

Temporary tieback anchors or soil nails may be used beneath streets, at intersections, under parking areas, and beneath existing buildings where easements can be obtained. We recommend use of soil nail walls to support the majority of the vertical excavations. The presence of fill materials overlying dense, native soils should be evaluated by the soil nail wall designer. Vertical elements and/or prestressed nails may be required. In areas where wall and ground deflections need to be limited, prestressed bracing or tieback anchors should be used to limit deflections.

5.3.2 Lateral Resistance

The computer program LPILE^{PLUS} 4.0 by Reese et al. (2002) may be used to generate PY curves for the lateral resistance analysis of cantilevered soldier piles and to calculate the magnitude of deflection, shear, and moment along the pile. The structural design engineer may use this program and the appropriate soil and pile stiffness values to evaluate pile lateral performance. Based on subsurface conditions, as interpreted from the field explorations, we recommend the following strength parameters for LPILE analysis of dense to very dense glacial outwash soils:

- Cohesion = 0
- Friction Angle = 42 degrees
- Effective unit weight (below groundwater) = 63 pounds per cubic foot (pcf)
- Horizontal Modulus of Subgrade Reaction = 150 pounds per cubic inch (pci)

5.3.3 Lateral Earth Pressures

Lateral earth pressures for design of temporary shoring walls incorporating our recommendations and the LRFD load and resistance factors are presented in Figure 6. This diagram provides pressures for cantilevered soldier pile walls, walls with a single row of tiebacks or braces, and walls with multiple rows of tiebacks or braces. The pressures shown in Figure 6 are based on the assumption that the excavation is dewatered. Applicable lateral pressures from surcharge loads, as determined from Figure 8, should be added to the pressures shown in Figure 6. We recommend using diagram D in Figure 8 for estimating surcharge pressures due to equipment and material stockpiles. A "K" value of 0.4 may be used in conjunction with this figure. We recommend using diagram A in Figure B for estimating surcharge pressures due to the footing loads from existing garage buildings on Burwell Street.

5.3.4 Estimated Ground Movements

The excavation for the tunnel alternative will result in both vertical and horizontal ground movements outside of the excavation support systems. The magnitude and extent of these movements will depend on the nature of the subsurface soil and groundwater conditions, excavation depths, dewatering requirements, construction sequence and procedures, and the stiffness of the excavation support system. Based on the distance of the proposed alignment to buildings that will remain during construction, we expect there would be no significant settlements of existing buildings as a result of the proposed excavation.

Based on local (Seattle) case histories for excavations in soils similar to those present in Bremerton, we anticipate that the maximum lateral movements and vertical settlements of soldier pile and lagging walls with prestressed tieback anchors or preloaded bracing would range from about 0.5 to 1 inch for a 40- to 50-foot-deep excavation. Most of this movement and settlement would occur within a distance from the shoring equal to about 50 percent of the shoring height.

Soil nail shoring systems typically result in lateral deflection and adjacent ground surface settlements of 1 to 2 percent of the excavation depth. These settlements and movements typically occur within a distance from the excavation equal to approximately 80 percent of the excavation height, with the greatest movements occurring within about 10 feet of the shoring wall. Therefore, soil nailing should not be used where adjacent structures and buried utilities cannot tolerate this magnitude of movement and settlement.

5.3.5 Estimated Settlements Due to Dewatering

In general, we expect that dewatering for the tunnel construction would not cause detrimental settlement of the adjacent ground because the native soils are glacially overridden and are not susceptible to settlements caused by groundwater drawdown.

5.3.6 Shoring Wall Performance Criteria

Considering the potentially sensitive structures adjacent to the tunnel excavation and the need to restrict wall movements, criteria should be developed to assist in evaluating the performance of the shoring system during construction. The performance criteria will be based on the proximity of adjacent structures and their ability to tolerate settlement and lateral movement. The performance of the wall should be monitored during construction by instrumentation as discussed subsequently.

We recommend establishment of a two-stage performance criterion for each section of shoring walls adjacent to buildings as follows:

- Limiting inward horizontal movement at any point on the shoring wall to ½ inch.
- Establishing a maximum allowable inward horizontal movement at any point on the shoring wall of ¾ inch.

For walls supporting streets and parking lots, the limiting and maximum values can be increased to 1 and 1.5 inches, respectively. These increased limits will be subject to City of Bremerton approval and should not be used if sensitive utilities can be affected.

Limiting values of inward wall movement are intended to represent a level of wall movement that warrants attention by the Contractor. If limiting values occur, the Contractor should notify the Engineer and be prepared to implement mitigating measures to reduce or arrest the movement. Monitoring of wall systems should be undertaken at more frequent time intervals if limiting values occur.

In the event that maximum allowable values of inward wall movement occur or are being approached, the Contractor should terminate construction activities in the area and immediately implement mitigating measures. The Contractor should be required to submit, as part of his design, a comprehensive program of mitigation measures to be undertaken in the event that inward movement of the shoring wall approaches or reaches the maximum allowable value.

5.3.7 Soldier Piles

Vertical members of the temporary shoring system for the tunnel may consist of soldier piles, i.e., steel sections embedded into predrilled holes. In addition to supporting earth pressures, they should also be designed for the vertical component of tieback anchor forces, if used.

Vertical soldier pile capacities below the bottom of the excavation can be evaluated from the skin friction and the end-bearing pressures given in Figure 6. As shown, the skin friction within 2 feet of the bottom of the excavation should be neglected.

In addition to vertical load capacity, penetration depth below final excavation level should also be adequate for kickout resistance. Recommendations for determining pile embedment are included in Figure 6. We recommend that soldier piles penetrate at least 8 feet below the bottom of the excavation.

The shoring contractor should anticipate drilling through water-bearing silts, sands, and gravels that may cave during drilling. Caving can usually be controlled by dewatering, using temporary steel casing or slurry techniques. In addition, the Contractor should anticipate drilling through cobbles and boulders and fill debris that includes such materials as wood, brick, concrete, and other obstructions.

5.3.8 Lagging

The majority of the soils to be retained consist of silty sand and gravelly sand, which will tend to slough and erode as a vertical excavation face is made. Lagging should be installed between soldier piles to retain the soil. The lagging should be installed as the excavation proceeds, and not more than 3 feet, measured vertically, of unsupported excavation should be exposed at any time. Void space behind the lagging should be filled with free-draining material such as clean sand derived from the excavation. The Contractor should provide weep holes between the lagging boards to prevent the buildup of hydrostatic pressure, if necessary.

Because of soil arching between soldier piles, a reduced lateral earth pressure may be used for the design of the lagging. We recommend designing the lagging using 50 percent of the lateral soil pressure recommended for shoring design. This reduced soil pressure should be uniformly distributed over the length of the lagging. Generally, 4-inch-thick treated timber Douglas fir No. 2 or better ($f_b > 1{,}200$ pounds per square inch [psi]) is sufficient to provide adequate support between soldier piles at a clear spacing of 10 feet or less. However, high surcharge loads may necessitate thicker or stiffer lagging material at some locations.

5.3.9 Tieback Anchors

Tieback anchors are planned where feasible based on rights-of-way and existing underground structures. Tiebacks should have a minimum diameter of 6 inches and should be post grouted. The spacing between tiebacks should be a minimum of 4 feet. The bonded length of each tieback anchor should be located outside the "No Load Zone," as shown in Figure 6. The bonded length should be located in dense to very dense, glacial outwash soils.

The nominal bond stress (pullout resistance) of augercast tiebacks is estimated to be 2.1 kips per square foot (ksf) in dense glacial outwash soils, based on the conditions encountered in the borings and our experience with tiebacks in similar soils. To calculate the pullout resistance of the anchors in granular soils, we recommend that a resistance factor of 0.65 be used in conjunction with the nominal bond stress, per AASHTO LRFD Bridge Design Specifications (2005). Augercast tiebacks are installed using tremie grouting methods, where cement grout is placed through the hollow-stem auger with minimal pressure. Post-grouted tiebacks can generally develop much higher bond stress. We recommend that post-grouted tieback anchors be designed for a nominal (ultimate) anchor bond stress of 3.8 kips per square foot (ksf). An anchor pullout resistance factor of 0.65 should be used to determine factored anchor pullout resistance. Since the load transfer of tieback anchors is dependent upon many factors, including the Contractor's equipment, methods, experience, and care of installation, the anchor lengths of production tiebacks should be based on a series of test anchors installed using the same equipment and methods as the production tiebacks.

The Contractor should be prepared to drill through and install anchors in very dense soils where cobbles and boulders may be encountered. Timber, concrete, brick, and other types of debris may be encountered while drilling through fill. Groundwater may cause caving in the anchor holes. Anchor holes should be drilled in a manner that will minimize loss of ground and not undermine existing foundations or utilities. For these reasons, the Contractor should be prepared to drill, grout, and install all tiebacks using casing. We recommend that anchor holes in the no-load zone not be left open overnight.

In the anchor no-load zone, a bond breaker should be used around the tieback tendons or bars. A minimum 12-inch-long buffer zone of loose sand or filler material is required directly behind the soldier pile to prevent tieback forces from transferring to the grouted annulus.

All temporary anchors should be installed to achieve twice the design capacity, i.e., 200 percent of the design working load. All anchors should be proof-tested in accordance with WSDOT Standard Specifications for Road, Bridge and Municipal Construction.

5.3.10 Soil Nail Shoring

In general, the site is underlain by very dense, glacially overridden, granular soils at relatively shallow depths. Soil nail shoring walls typically perform well in these soils and may be considered for use as temporary shoring for this project. While some portions of the alignment contain a surface fill layer of variable thickness and composition, a properly designed soil nail wall can accommodate surface layers of weaker fill material by using design elements such as flatter slopes at the top of the wall or prestressed vertical beams to support the surface soils. Based on the proposed alignment and the condition of the soils, we recommend that soil nail shoring be considered by the Contractor to support the excavation where vertical cuts are needed. The soil nail shoring can be constructed as a "top-down" temporary wall. Soil nail shoring design should follow the guidelines provided by the Federal Highway Administration (FHWA) Geotechnical Engineering Circular #7, Soil Nail Walls, publication number FHWA IF-03-017, March 2003. Additional test borings are recommended to confirm subsurface conditions and to comply with the guidelines of Circular No. 7. These should be performed by the Contractor prior to final design of the soil nail shoring.

Soil nailing consists of drilling and grouting a series of steel bars or "nails" behind the excavation face and then covering the face with reinforced shotcrete. The placement of relatively closely spaced steel nails in the retained soil mass increases the shear resistance of the soil against rotational sliding, increases the tensile strength of the soil behind potential slip surfaces, and moderately increases shear resistance at a potential internal slip surface because of the bending stiffness of the nails.

Soil nailing is most effective in dense, granular soils and stiff, low plasticity, fine-grained soils. Soil nailing may not be cost-effective in loose granular soils, soft cohesive soils, highly plastic clays, or where uncontrolled groundwater exists above the bottom of the excavation. In general, up to 8-foot vertical excavation faces must be able to stand unsupported for 24 to 48 hours in order for soil nailing to be feasible. The length of exposed cut faces will depend on actual encountered soil and groundwater conditions.

Soil nails consist of steel bars (typically ¾- to 1⅜-inch-diameter), which are installed by tremie grouting the nail into a predrilled hole. Soil nails are located in a rectangular or triangular grid pattern and are typically installed at a declination angle of 15 degrees from horizontal. The construction sequence of a soil nail wall generally includes three steps: (a) staged excavation, (b) nail installation and select nail testing, and (c) drainage and facing construction. This sequence is repeated until the excavation and shoring are complete.

Soil nail construction is performed as excavation proceeds from the ground surface down. In general, the first row of nails is installed not more than 2 to 4 feet below the ground surface, and the bottom row of nails is installed not higher than 4 feet above the bottom of the excavation. Nails are installed in horizontal rows around the excavation perimeter after excavation proceeds 2 to 3 feet below the planned nail elevation. Excavation can proceed ahead of nail installation in the center portion of the proposed tunnel excavation, i.e., away from soil nail wall construction area.

For the soil nail wall design, we recommend the following strength parameters for the fill and glacial outwash at the site, as shown in Table 4.

Based on information obtained in the explorations, groundwater will be encountered within the base of the proposed excavation. Thus, dewatering within the lower portion of the tunnel excavation and shoring should be anticipated at the site.

TABLE 4
SOIL NAIL STRENGTH PARAMETERS

Soil Type	Moist Unit Weight (pcf)	Angle of Internal Friction (degrees)	Soil Cohesion (psf)	Ultimate Pullout Resistance[1] (klf)
Native, glacial outwash	135	40	500	7.0
Fill material	125	32	150	3.0

Notes:
[1]This is based on a typical 7-inch diameter soil nail.
klf = kips per linear foot
pcf = pounds per cubic foot
psf = pounds per square foot

Typically, soil nails have a closer spacing and are longer when used in fill soils. Temporary soil nail shotcrete facing may need to be thicker and have more reinforcing to maintain stability in fill soils, and the "stand up" time and depth for each level of excavation may be limited. Alternatively, vertical elements such as grouted reinforcing bars, pipes, or small beams can be installed to improve stability in fill soils.

With every excavation in soil, both elastic and inelastic ground displacements will occur behind the earth support system as a result of changes in stresses within the surrounding soil mass. The displacement magnitudes are dependent upon stress-deformation properties of the soil; design lateral earth pressures; the configuration, stages, and depth of excavation; wall stiffness; spacing of soil nails; groundwater conditions; and the care and skill with which the excavation work is accomplished.

5.3.11 Instrumentation

A geotechnical instrumentation program is recommended to assist in monitoring, documentation, and quality control during construction. The primary objectives of the instrumentation program are to:

- Indicate whether or not the excavation procedures used are maintaining settlements within acceptable limits.
- Provide early warning of adverse trends.
- Determine when ground modifications (such as underpinning and grouting) need to be implemented to protect structures.

- Monitor the degree to which these protective or remedial measures are limiting damage to structures and provide early warning when alternative means of protection are necessary.
- Provide data for settling legal disputes between either the Contractor and the Owner or with owners of adjacent structures.
- Confirm design assumptions and provide data that can improve future designs.

Instrumentation should be installed prior to construction and be used to measure groundwater levels, deformations, loads, and vibrations. Groundwater parameters should include piezometric elevations and flows around and within the excavation. Deformations should be monitored, including horizontal and vertical movements of the excavation support system, soils adjacent to the excavations, and adjacent structures and utilities. The measurement of loading may include lateral loads in the excavation support systems. Construction vibrations should be monitored to evaluate the potential for cosmetic or structural damage of adjacent structures.

We recommend the instrumentation be purchased and installed by the Contractor, with review by the Engineer. Furthermore, we recommend that the Engineer be responsible for reading the instruments, interpreting the data, and reporting the measurements to the Owner and Contractor.

5.3.11.1 Preconstruction Survey

Before starting instrumentation or construction, a thorough inspection survey of all buildings and structures along the alignment should be undertaken. The survey should document the existing condition of each structure with sketches and photographs. These records should include, but not be limited to, data such as the length and width of existing cracks, number of cracks, locations of water marks, condition of door and window jams, condition of paint, and other features. The surveys should be conducted with representatives of the building owner, Contractor, Engineer, and project Owner. A formal report of every structure should then be developed and signed by each member of the group.

5.3.11.2 Instrumentation Types

The shoring walls for the tunnel excavation will likely deform laterally and the support system will be loaded as the excavation deepens. Lateral deformations of the shoring walls will likely result in vertical settlements outside the excavations, which can affect adjacent structures, utilities, and pavements. The recommended instrumentation systems to monitor the deformations and loads are as follows:

- Inclinometer casings for monitoring lateral deformations of shoring walls and adjacent soils.
- Strain gages for monitoring stresses in support systems (internal braces) if applicable.
- Surface, utility, and building settlement markers for monitoring vertical settlement of the adjacent ground, pavement, utilities, and buildings.
- Horizontal offset survey markers for monitoring lateral deformations of buildings, pavements, retaining walls, and shoring.
- Crack meters for monitoring existing cracks or construction joints in adjacent structures.
- Piezometers for monitoring groundwater levels around the excavations in response to dewatering or excavation.

Discussions of the various applicable instrumentation installations are presented in the following sections.

5.3.11.3 Inclinometer Casings

Inclinometer casings typically consist of 2.75-inch outside-diameter (O.D.), internally grooved plastic pipe with self-aligning flush couplings. The casings are installed into a borehole or onto an element of the shoring wall prior to excavation. An inclinometer probe is used to measure the inclination of the casing at regular intervals of about 2 feet. Lateral deformations are determined by comparing the current inclination of the casing with previous measurements. If the inclinometer casing is installed deep enough so that the bottom of the casing is assumed to be fixed, the position and lateral displacement of the casing can be accurately computed using geometrical relationships. The normal accuracy of inclinometer measurements is about ±0.10 inch over a 100-foot length of casing, although greater accuracy is possible using experienced personnel, consistent monitoring techniques, and mathematical corrections.

Inclinometer casings are recommended to be installed within the shoring walls at a spacing of not more than 200 feet along the internally braced excavations. For tied-back shoring, a closer spacing should be considered. The actual locations of the inclinometer casings should be determined by the Engineer prior to the installation. This should be accomplished by attaching a 6-inch-diameter steel pipe to the steel section of the shoring wall. After completion of the shoring wall, but prior to any excavation, a borehole will be advanced to the bottom of the shoring, and the inclinometer casing will then be installed into the borehole and grouted in place with a cement grout. Alternatively, a square steel tube (nominal 1.5 inches) can be attached to the steel section of the shoring wall and used as the inclinometer casing.

5.3.11.4 Strain Gages

The DP/BTC tunnel excavation support system will incorporate tieback anchors and, possibly, internal bracing. Stresses on these components are recommended to be monitored during construction using strain gages to measure loads in internal bracing.

Weldable vibrating-wire strain gages should be installed on internal braces that are adjacent to the inclinometer casing installations. At each casing location, the gages should be installed at multiple bracing levels and on three adjacent braces. The strain gages should be installed at four equidistant points around the circumference of each brace and should be located at least four brace diameters or widths from one end of the brace. Protection is critical during construction, and instrumentation should be designed with protective covers for the gages and conduits for the gage leads. The mounting technique for the protective covers should be designed so that it does not affect the strain gage readings.

5.3.11.5 Survey Markers

Survey markers should be established on streets and sidewalks, and on exterior walls of adjacent buildings. In addition, survey markers may be required on shallow utilities, interior building columns, retaining walls, and other areas as necessary to monitor vertical and horizontal movement. Similarly, the tops of temporary shoring walls should be surveyed to assess vertical and horizontal movements of shoring elements.

For surface settlement, settlement points should be established both parallel and perpendicular to the excavation. Data from the perpendicular settlement points will assist in determining angular distortions of adjacent buildings, pavements, and utilities. In addition, survey points established near the tops of buildings will assist in determining angular distortion.

Vertical and horizontal points should be installed along the exterior walls of adjacent buildings. The points should be installed at each column location along walls that are parallel to the excavations, and on columns located along perpendicular walls and within a distance of three times the excavation depth. Shoring walls should also have vertical and horizontal survey points established on the tops of soldier piles every 30 feet to supplement inclinometer data.

Buried utilities may require survey markers to monitor potential settlement. These points typically require potholing above the utility and placement of a settlement plate with extension rod and sleeve; alternatively, an extension rod and sleeve can be fixed to the utility. Although the extension rod is adequate for vertical survey, it is not acceptable for horizontal surveys. If the measurement of horizontal movement is required, an inclinometer casing is the best alternative.

5.3.11.6 Crack Meters

Manual and/or electrical crack meters should also be installed across existing cracks on both interior and exterior walls and structural elements of the adjacent buildings. The crack meters should be installed across existing cracks defined during the preconstruction survey, and the data should be used to document any changes during construction. Electrical crack meters are installed for monitoring interior cracks and can minimize disruption of building occupants when taking readings.

5.3.11.7 Piezometers

To monitor the performance of dewatering systems, piezometers installed in two existing borings (SW-3 and SW-5) located outside the excavation limits should be monitored during construction. Additional piezometers are recommended.

The piezometers could consist of observation wells and/or vibrating wire transducers. Observation wells should consist of 2.0-inch O.D., Schedule 40, polyvinyl chloride (PVC) pipe having 0.010-inch slots embedded in clean, coarse sand. The sand zone is typically sealed by placing several feet of bentonite pellets or chips above the sand filter, followed by bentonite grout to the surface. As an alternative, vibrating wire transducers can be installed in the sand filters instead of the observation wells. The vibrating wire transducers can be installed at multiple levels within a single borehole, if necessary, to allow groundwater levels in various geologic units to be monitored efficiently.

5.3.11.8 Vibration Monitors

Vibration levels necessary to cause structural damage, i.e., where peak particle velocities are greater than 2 inches per second, are not expected to occur during construction of the tunnel project. However, architectural damage, which includes cracking of masonry, plaster, and stucco, can occur at levels as low as 0.5 inch per second.

Vibration levels are typically monitored using seismographs that are capable of measuring various parameters including the magnitude of ground displacement, frequency, peak particle velocity, and acceleration of each measurable event. The anticipated responses of structures to a given vibration level are commonly based on peak particle velocity and frequency. Consequently, each seismograph should have the ability to be triggered by a minimum event and should record at least the date, time, peak particle velocity, and frequency of the event.

Seismographs could be located in buildings adjacent to the excavation that may be susceptible to vibration damage such as masonry, stucco, and plaster, and those next to intensive or repetitive construction activities such as pile installations and muck hauling areas. In addition, seismographs should be used to monitor vibration levels adjacent to critical or older utilities such as water or gas pipelines, if any.

5.3.11.9 Monitoring Frequency and Data Reporting

Monitoring frequency will vary for each of the instrument systems and for each phase of construction. Gages installed prior to construction should be read at least four times at least one week apart to provide a stable baseline. Instruments may require monitoring on a daily to weekly basis depending on the rates of excavation. Generally, a reading should be taken during excavation for each 5 to 10 feet of depth increase.

All collected data should be promptly reduced and presented in useful, legible, and well-labeled plots. In general, the plots should include construction information on depths and stationing of the advancing excavation. Plots will also include geotechnical data, including soil layers and groundwater levels, or other features that may impact the interpretation of the data.

Since the collected and reduced data may be critical to assessing the ground movement project, the data should be made available daily to the Contractor and Owner. The reduced and interpreted data should be summarized in a brief memorandum with recommendations for altering construction procedures, if appropriate.

5.4 Design Criteria for Permanent Walls

We understand that permanent walls for this project will include the tunnel walls and cantilevered concrete walls at the north and south portals, and at the northeast corner of the United States Navy (Navy) property. These cantilevered concrete retaining walls are less than 25 feet high, with the exception of wall W-3 on the Navy property, which is 34 feet high. Thus, they may be designed in accordance with WSDOT standard plans for Type 1 Reinforced Concrete Retaining Walls.

Additionally, there will be a series of security walls and terrace walls constructed within the landscaped public plaza (Memorial Park) areas above the tunnel alignment between approximate Stations 14+00 and 20+00. The walls in the landscaped plaza will generally range from 1 to 3 feet high and will provide planting areas and barriers. There will also be a concrete security wall extending along the east side of the plaza between Navy property and the public plaza. This wall will extend from First street to Burwell Street and will range from approximately 7 to 12 feet high. It will provide a barrier as well as support 5 to 10 feet of fill that will be placed for the public plaza area. Subsurface conditions below the proposed plaza area walls have not been specifically investigated because of the presence of existing buildings over the area (with the exception of boring SW-4 at Station 16+00). However, based on nearby soil borings on Pacific Avenue and 1st Street, we expect that foundation bearing soils would consist of loose to dense silt and sand fill materials. For design purposes, we assume that the exposed soils at these wall locations would consist of medium dense sand. All subgrades will have to be evaluated during construction to confirm acceptable bearing soils. Overexcavation and replacement with compacted structural fill may be necessary to maintain medium dense or better foundation subgrades at each wall location.

The majority of the permanent walls for this project will bear in dense to very dense, granular outwash soils. Based on soil boring TH-1-02, excavations for wall W-2 may encounter older backfill soils placed behind the Navy retaining wall along Burwell Street. We expect that the Navy wall was built with a sloping cut and, therefore, the backfill would be localized to just behind the Navy wall. Therefore, we have provide a lower allowable bearing pressure for design of W-2 in the event that medium dense to dense backfill soils are present. At the W-2 wall foundation elevation.

Based on the subsurface conditions at each retaining wall location and we have developed the following table of values for allowable soil bearing pressure, estimated settlements, and overall stability for the maximum wall height.

TABLE 5
STANDARD PLAN WALL DESIGN VALUES

Wall Designation	Location (Stationing)	Allowable Bearing Pressure (ksf)	Estimated Settlement (inch)	Factor of Safety for Overall Stability (Seismic Condition)
W-1	10+10 to 12+31	11	< 1.0	>1.5
W-2	10+10 to 12+31	6	< 1.0	>1.6
W-3	13+32 to 15+27	11	< 1.0	>1.35
W-4	21+90 to 24+65	11	< 1.0	>1.5
W-5	21+90 to 23+80	11	< 1.0	>1.5
Security Walls	Various	2	< 1.0	>2

Note:
ksf = kips per square foot

5.4.1 Cantilevered Walls

Cantilevered retaining walls at the west tunnel portal will bear at elevations ranging from 10 feet to 20 feet. This grade change occurs over a wall length of approximately 250 feet. This is about a 4 percent slope and, in our opinion, the footings for these walls may be cast on the sloping ground rather than being cast on level subgrade with a series of steps to make the grade changes. Similarly, the wall footings at the east portal may also be cast on gently sloping subgrade. We recommend that an ultimate coefficient of friction of 0.45 be used to estimate sliding resistance between cast-in-place concrete and native soils.

Based on groundwater observations wells SW-1 and SW-6, located near the south and north portals, respectively, we expect that naturally-occurring groundwater levels would be below the bottom of the wall retaining footings. Permanent dewatering of the walls would not be a design issue, however, we recommend that free-draining backfill be used against the backside of the walls and drainage provisions, such as weep holes be included in the wall design.

5.4.2 Tunnel Walls

Lateral earth pressures for the design of the DP/BTC tunnel structure can be calculated using the pressure distributions presented in Figure 7. We understand that the tunnel design will include a buoyancy resistant floor slab and permanent drainage behind the tunnel walls will not be included. Therefore, hydrostatic pressures shown in Figure 7 should be included in the final design.

To determine dynamic earth pressures on the permanent tunnel walls we performed Mononobe-Okabe analyses. We used a horizontal acceleration coefficient of 0.35g, which is the PGA for a seismic event with a 10 percent probability of exceedance in 50 years (475-year return period event). The recommended dynamic earth pressure distribution for the permanent tunnel walls is shown in Figure 7.

The thickness of the two general soil units (fill and glacial outwash) and the groundwater levels vary along the tunnel alignment. Therefore, wall design pressures can be estimated for various alignment segments using the pressures in Figure 7 in conjunction with the subsurface geologic profile presented in Figure 5. Lateral pressures, such as those exerted on the structure from adjacent material stockpiles, should be estimated from the relationships shown in Detail D of Figure 8 and added to the design pressures presented in Figure 7. A "K" value of 0.4 is recommended in conjunction with Figure 8.

For permanent tunnel wall footings, we recommend that an ultimate bearing pressure of 34 ksf with a resistance factor of 0.35 be considered for foundation design at the strength limit state per AASHTO LRFD Bridge Design Specifications (2004).

The roof of the cut-and-cover tunnel should be designed to support the overburden pressure above the tunnel plus the traffic load and other live loads. Overburden pressure can be estimated using a soil unit weight of 130 pcf.

5.5 Foundation Design Recommendations

It is assumed that a soil structure interaction analysis will be used for design of the mat foundation supporting the tunnel structure. Based on the results of the soil borings along the alignment, mat foundations would bear on overconsolidated glacial outwash (Qo) deposits or compacted structural fill. For this analysis, it is recommended that a vertical coefficient of subgrade reaction value equal to 200 pci be used to model the soil resistance in very dense glacial outwash or compacted structural fill.

5.5.1 Spread Footings

Spread-footing foundations for the tunnel portal retaining walls and wall W-3 on the Navy property may be designed for an ultimate bearing pressure of 34 ksf with a resistance factor of 0.35, in accordance with AASHTO LRFD Bridge Design Specifications (2005). The aforementioned bearing capacity recommendation is for spread footings bearing on very dense outwash soils in which the base of the footing is located at least 2 feet below the adjacent finished grade. We estimate that foundations bearing under this pressure would experience settlements on the order of 1 inch.

Based on the results of soil borings SW-1 and SW-2, very dense glacial outwash soils are likely to be present at the proposed location of the ferry toll booths. We recommend that the foundations for the toll booths consist of spread footings designed in accordance with IBC 2003 guidelines and an allowable bearing pressure of 10 ksf.

5.5.2 Uplift Resistance

Uplift is normally caused by buoyancy forces acting on the portion of the structure located below the groundwater table. Based on the monitoring wells installed along the project alignment, ground water may rise to approximately 8 feet above the proposed tunnel invert. We understand that the tunnel walls and floor slab will be designed to withstand hydrostatic pressure.

5.5.3 Signal Pole Foundations

We understand that there will be new signal poles installed at the intersections of Burwell and Park and Burwell and Pacific, and at the west tunnel portal. Based on soils encountered in borings at these locations, we recommend that the pole foundations at Burwell and Park be designed for a lateral bearing pressure of 1,500 pounds per square foot (psf), and the other two signal pole foundations be designed for a lateral bearing pressure of 2,500 psf using WSDOT Standard Design Methods. Soil conditions at the pole foundations should be evaluated by the geotechnical engineer during construction.

6.0 EARTHWORK RECOMMENDATIONS

6.1 Subgrade Preparation

The sand, silt, and gravelly soils at the bottom of the tunnel excavation will likely be wet where the groundwater table is intercepted, i.e., south of Station 16+00. Special measures may be necessary to reduce disturbance of wet subgrade soils even if dewatering is accomplished. These measures may include overexcavating and placing a gravel fill or crushed rock as a working base, or maintaining the excavation bottom 1 foot above grade for working purposes, and then excavating to final grade immediately before foundation construction.

Disturbed, loose, and soft soils in the subgrade should be removed and replaced with compacted structural fill. The subgrade should be proof-rolled to provide a uniform, dense, and unyielding surface prior to placement of reinforcing steel for the mat foundation. Should proof-rolling indicate the presence of soft or loose zones, the soils should be removed and replaced with compacted structural fill.

6.2 Fill Placement and Compaction

All fill placed behind walls and beneath structures, pavements, or other areas where settlements are to be minimized should consist of structural fill. Structural fill material should consist of a well-graded (fine to coarse) sand or sand and gravel mixture and it should be free of organic debris and other deleterious material. It should contain not more than 15 percent fines (material passing the No. 200 mesh sieve, based on the minus ¾ inch fraction) and the fines should be nonplastic. Structural fill should have a maximum particle size smaller than 3 inches.

In our opinion, much of the on-site, native soils that will be encountered in the tunnel excavation are suitable for reuse as structural fill; however, layers of silty sand and sandy silt will also be encountered in the excavation, and these soils will not be suitable for use as structural fill. Selective segregation of excavated materials will be necessary in order to remove the silty, moisture-sensitive soils from the structural fill stockpile.

Structural fill should be placed in uniform lifts and compacted to a dense and unyielding surface and to at least 95 percent of the Modified Proctor maximum dry density (American Society for Testing and Materials [ASTM] Designation: D 1557). The thickness of soil lifts should not exceed 8 inches for heavy equipment compactors or 4 inches for hand-operated mechanical compactors.

Areas to receive structural fill should be drained of any ponded water, and soils disturbed by work equipment should be removed prior to fill placement. For fills placed on properly prepared subgrade and compacted to 95 percent of the Modified Proctor maximum dry density, settlements would be on the order of 0.2 of 0.5 percent of the fill thickness.

6.3 Wet Weather Earthwork

The existing, on-site soils that will be encountered in the excavation contain sufficient amounts of silt to produce a cohesive, unstable mixture when wet. Such soils are highly susceptible to changes in water content and become difficult to work with during wet weather. The following recommendations are provided should wet weather earthwork be unavoidable:

- Soil stockpiles should be covered with plastic sheeting secured in place with sand bags.
- The ground surface in the construction area should be sloped to promote the rapid runoff of precipitation and to prevent ponding of water.
- Fill or backfill material should consist of clean, granular soil, of which not more than 5 percent (by dry weight) passes the No. 200 sieve, based on wet-sieving the fraction passing the ¾-inch sieve. The fines should be nonplastic.
- Earthwork should be accomplished in small sections to minimize exposure to wet weather and disturbance to the subgrade by work equipment.
- No fill should be left uncompacted and exposed to moisture. A smooth-drum vibratory roller should be used to seal the exposed surface.
- Soil that becomes too wet for compaction should be removed and replaced with structural fill less susceptible to moisture.

6.4 Construction Observation and Plans Review

The performance of the temporary shoring walls, foundations, and drainage is largely dependent on the quality and care used during construction. It is important to monitor the installation of soldier piles, tieback anchors, braces, drainage, and foundations to determine that they have been installed in a satisfactory manner. Therefore, we recommend that we be retained to evaluate the construction operations and review instrumentation to evaluate wall performance. We also recommend that we be retained to review those portions of the plans and specifications that pertain to these elements to determine if they are consistent with our recommendations.

7.0 LIMITATIONS

Within the limitations of scope, schedule, and budget, the conclusions and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical engineering principles and practices in the area at the time this report was prepared. We make no other warranty, either express or implied.

The analyses, conclusions, and recommendations contained in this report are based on our understanding of the project as described herein and site conditions as observed during our investigative work. For the purpose of presenting design recommendations, we assumed that the results of the explorations are representative of the subsurface conditions along the proposed project alignment; i.e., the subsurface conditions in the project area are not significantly different from those disclosed by the explorations.

If, during construction, subsurface conditions different from those encountered in the explorations are observed or appear to be present during excavations, we should be advised at once so we can review these conditions and reconsider our recommendations, where necessary.

Unanticipated soil and groundwater conditions are commonly encountered and cannot be fully determined on a large site such as this one by subsurface explorations and testing alone. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

This report was prepared for exclusive use by WSDOT, the City of Bremerton, Exeltech, and members of the design team for the design and construction of the DP/BTC project. This report should be made available to the prospective contractors and/or the Contractor for information on factual data only, and not as a warranty of subsurface conditions, such as those interpreted from the boring logs and discussions of subsurface conditions included in this report. Potential contractors for this project may only rely on the factual information provided in this report at the time, locations and elevations that it was obtained. Contractors and other third parties who are not part of the design team may not rely on interpretations, opinions, or judgments presented in this report without our prior written consent.

We have included Appendix D, "Important Information About Your Geotechnical Report," to assist you and others in understanding the use and limitations of this report.

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EXPIRES 4/21/ 08

Martin W. Page, P.E., L.E.G.
Associate

MWP:JW/mwp

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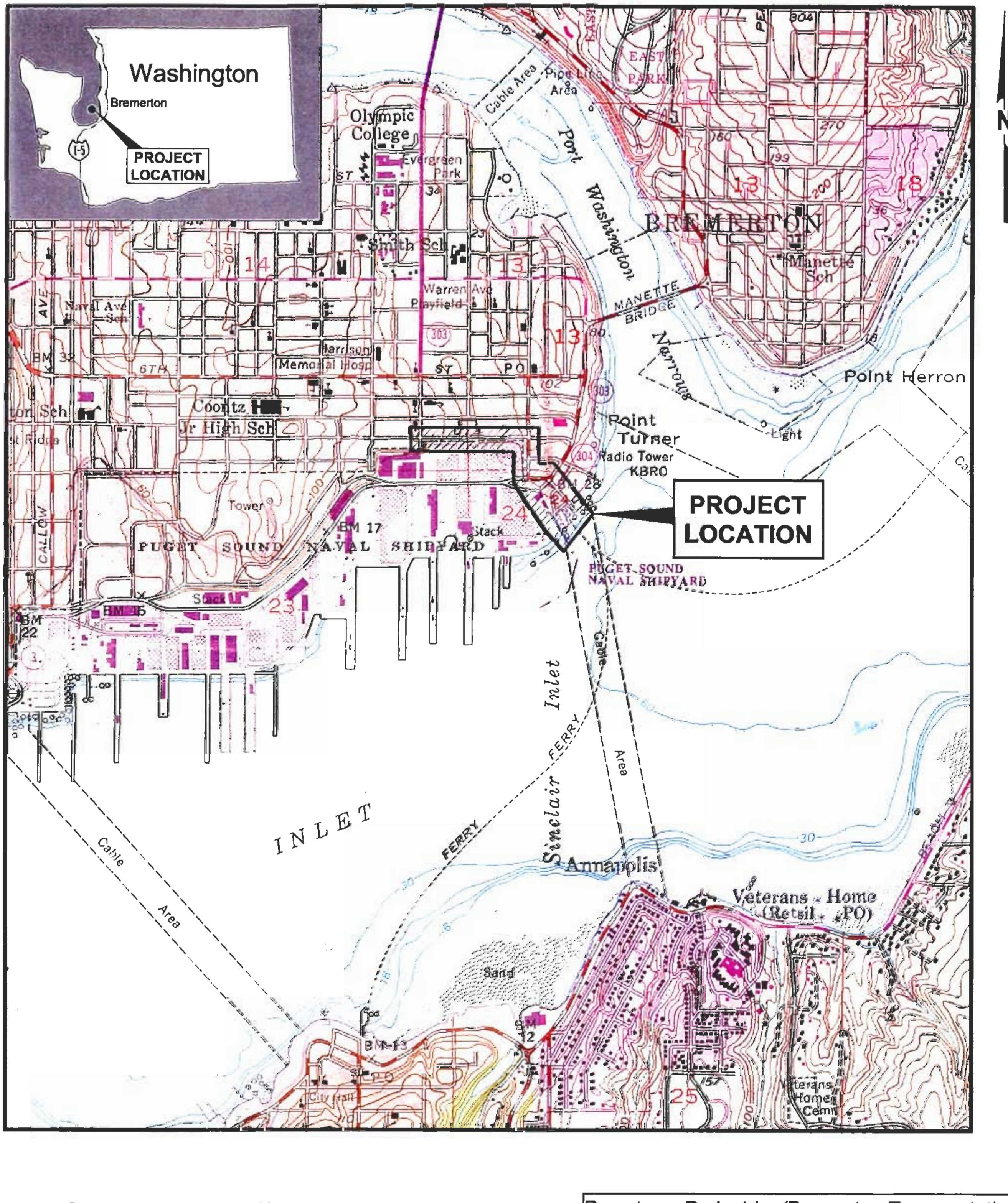
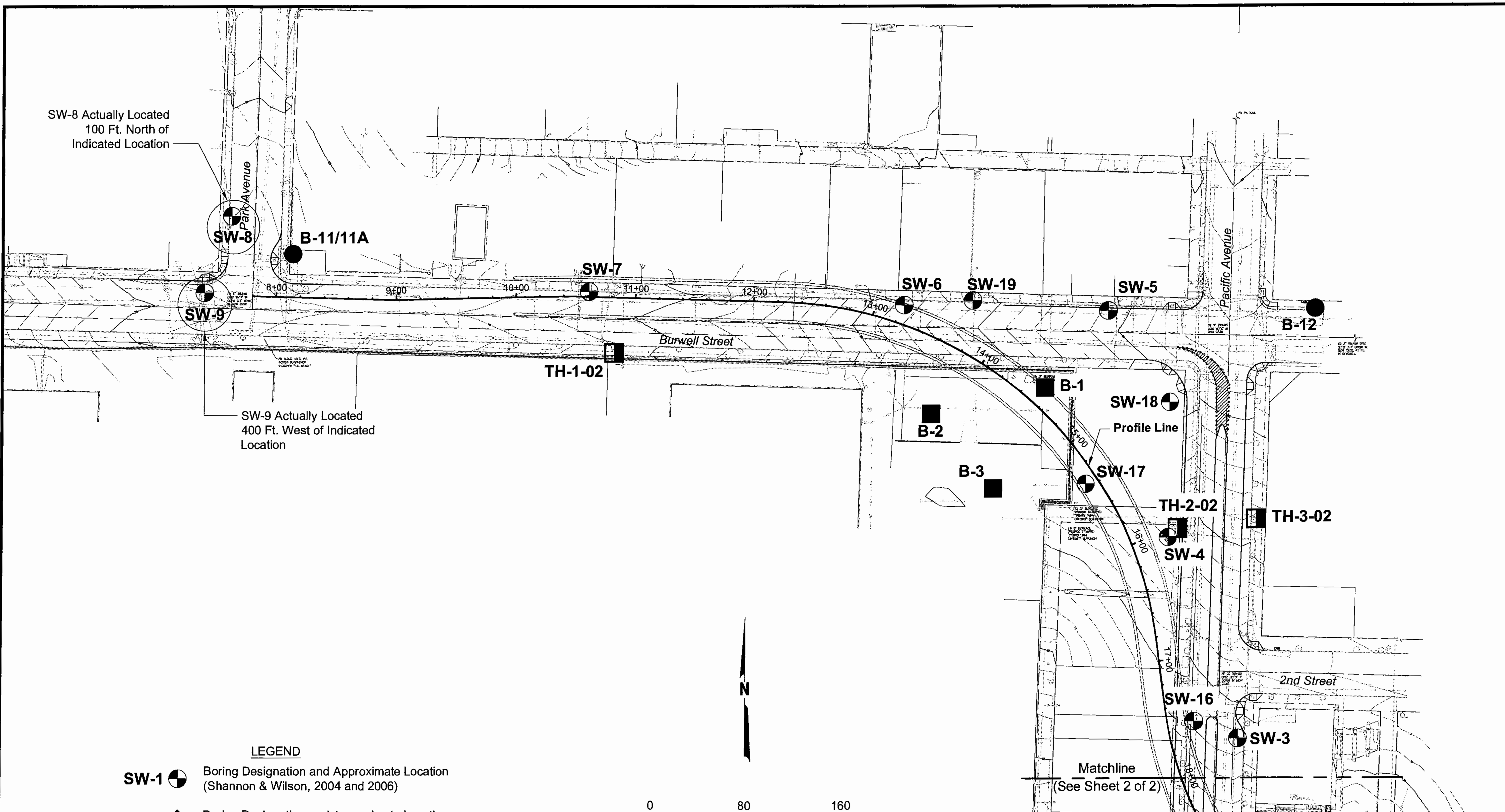


NOTE

Map adapted from 1:24,000 USGS topographic maps of Bremerton East and Bremerton West, WA quandrangles, both dated 1953, revised 1981 and 1973, respectively.

Downtown Pedestrian/Bremerton Transportation Center Access Improvements Bremerton, Washington	
VICINITY MAP	
July 2006	21-1-09948-003
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	**FIG. 1**

File: J:\211\09948-003\21-1-09948-003 fig 1(7-06).dwg Date: 07-18-2006 Author: draftemp



LEGEND

SW-1 — Boring Designation and Approximate Location (Shannon & Wilson, 2004 and 2006)

B-1 — Boring Designation and Approximate Location (Foster Wheeler, 2003)

TH-1-02 — Boring Designation and Approximate Location (WSDOT, 2002)

B-11 — Boring Designation and Approximate Location (CH2M Hill, 1988)

B-1 — Boring Designation and Approximate Location (Converse, 1983)

0 80 160

Scale in Feet

NOTE

Figure adapted from electronic files provided by Exeltech, dated 8-5-2005.

Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

SITE AND EXPLORATION PLAN

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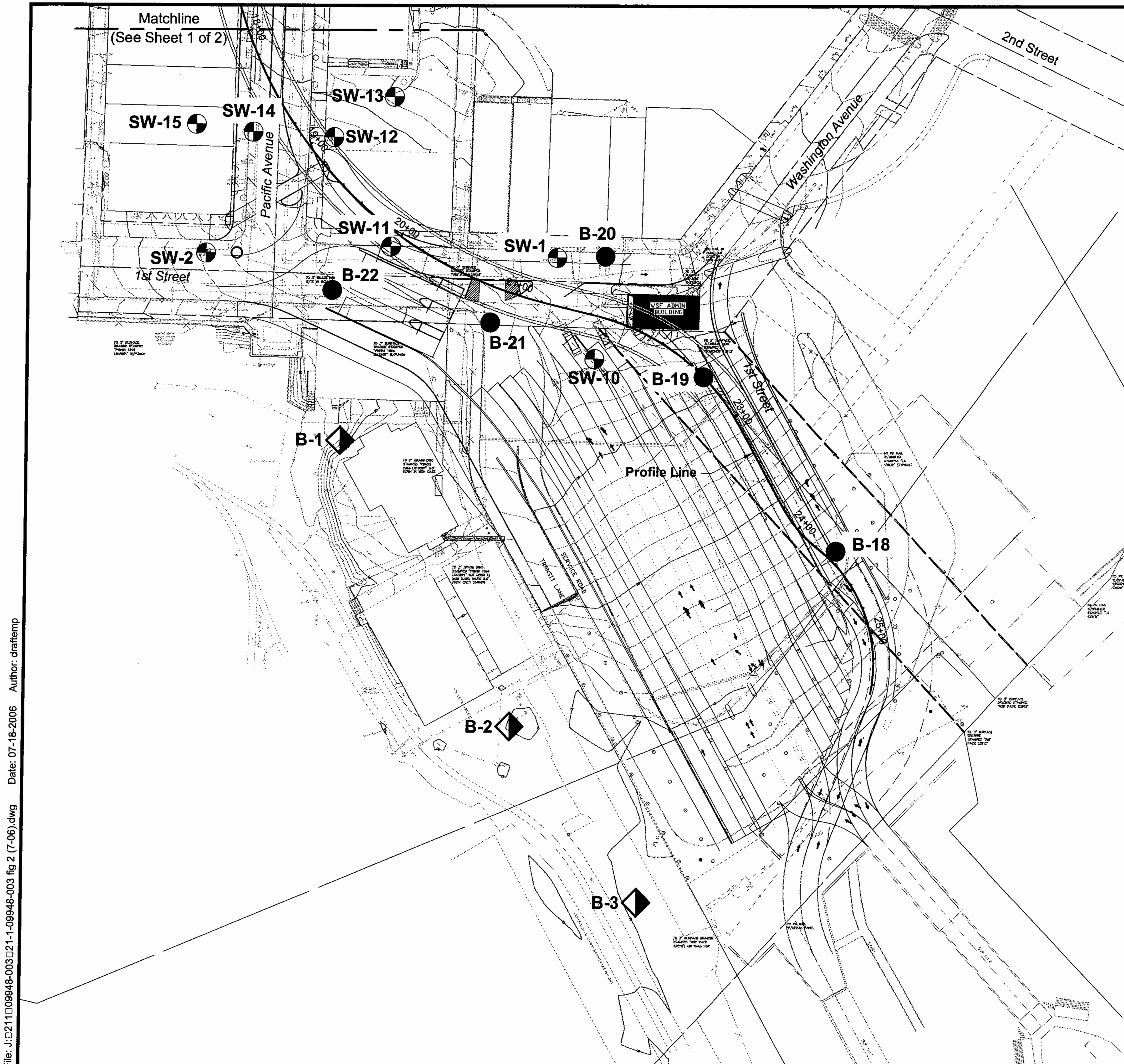
FIG. 2
Sheet 1 of 2

File: J:\211\09948-003\21-1-09948-003 fig 2 (7-06).dwg Date: 07-18-2006 Author: draftemp



LEGEND

SW-1	Boring Designation and Approximate Location (Shannon & Wilson, 2004 and 2006)
B-1	Boring Designation and Approximate Location (Foster Wheeler, 2003)
TH-1-02	Boring Designation and Approximate Location (WSDOT, 2002)
B-11	Boring Designation and Approximate Location (CH2M Hill, 1988)
B-1	Boring Designation and Approximate Location (Converse, 1983)

NOTE

Figure adapted from electronic files provided by Exceltech, dated 8-5-2005.

0 80 160

Scale in Feet

Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

SITE AND EXPLORATION PLAN

July 2006 21-1-09948-003

SHANNON & WILSON, INC.
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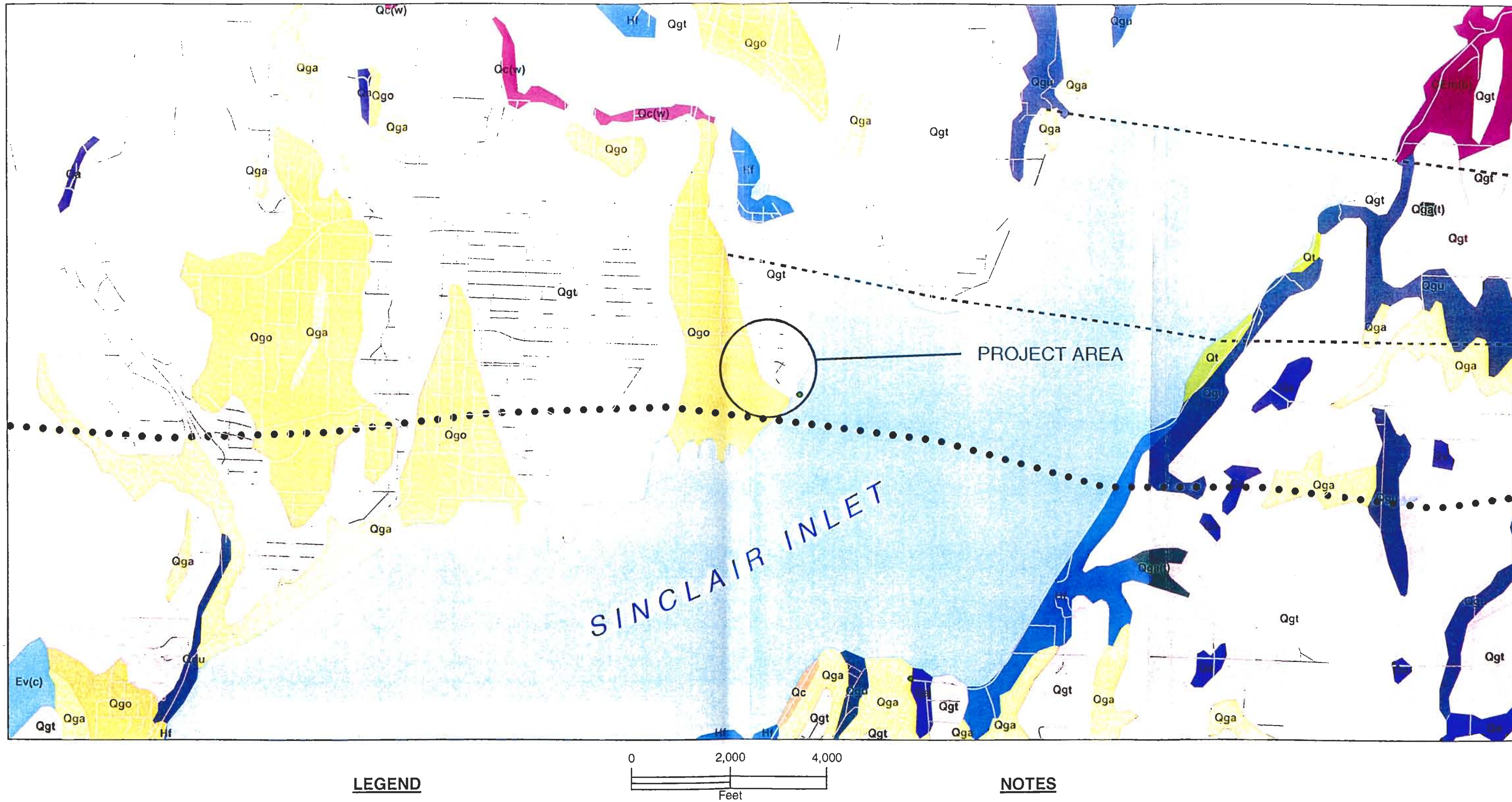
FIG. 2
Sheet 2 of 2

File: J:\211\09948-003\21-1-09948-003 fig 2 (7-06).dwg Date: 07-18-2006 Author: draftemp



LEGEND

- Hf- Fill
- Qa- Alluvium
- Qc- Sedimentary Deposits?
- Qc(w)- ?
- Qt- Terrace Deposits
- Qgo- Glacial Outwash
- Qgt- Glacial Till
- Qga- Advance Outwash
- Qga(t)- Transitional Beds
- Qgu- Undifferentiated Drift
- OEm(b)- Blakely Formation Marine Sedimentary Rocks
- Ev(c)- Crescent Formation Basalt
- ● ● ● ● Seattle Fault Trace (Blakeley, 2002)
- - - - - Seattle Fault Trace (Johnson, 1999)

NOTES

1. Geology base map from Digital Geologic Maps of the 1:100,000 Quadrangles of Washington, Seattle Quadrangle (Dracovich, 2002)
2. Geologic contacts and fault traces should be considered approximate.

Downtown Pedestrian and
BTC Access Improvements
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GEOLOGIC MAP

November 2005 21-1-09948-003

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FIG. 3

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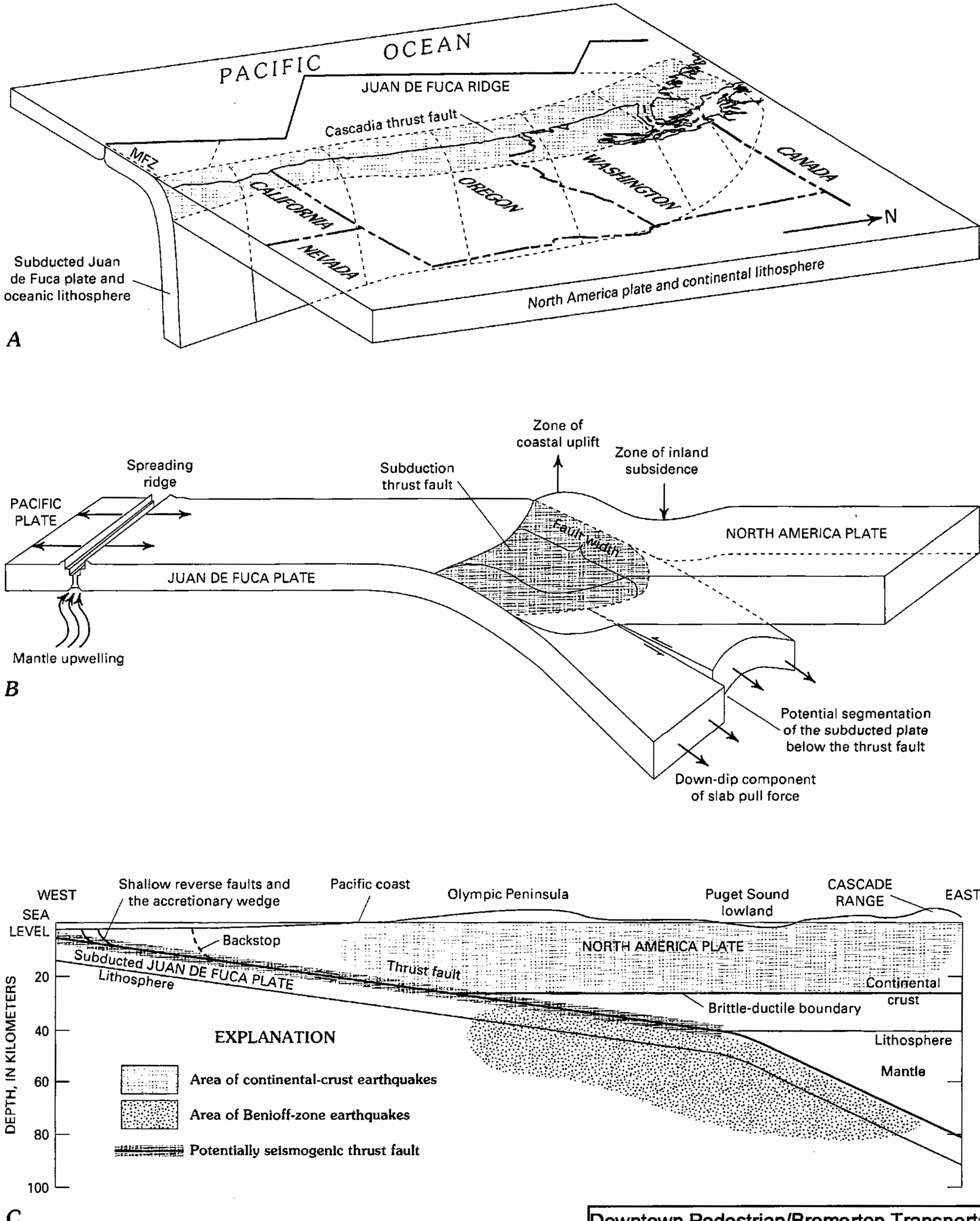

SOURCE

U.S. Geological Survey Professional Paper 1560.

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Bremerton, Washington

SCHEMATIC OF THE CASCADIA SUBDUCTION ZONE

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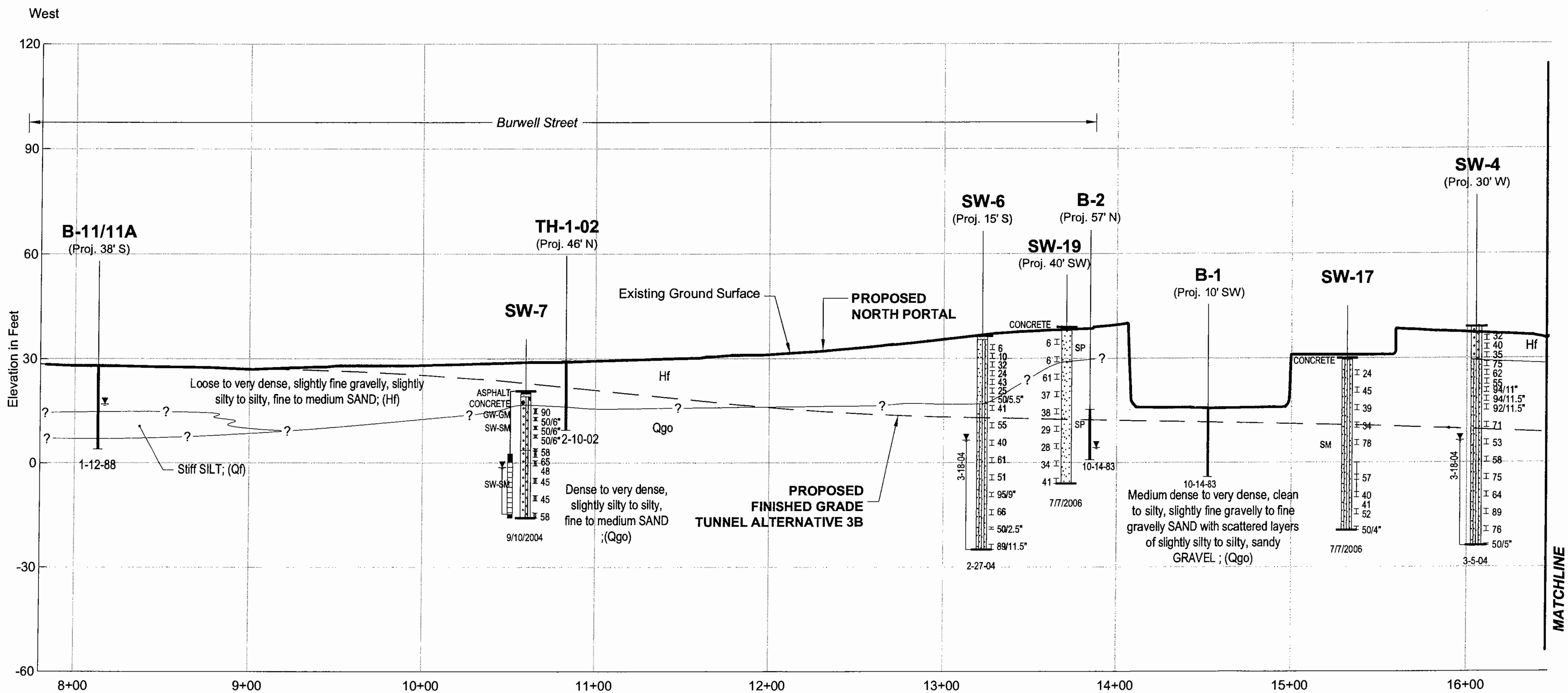
FIG. 4



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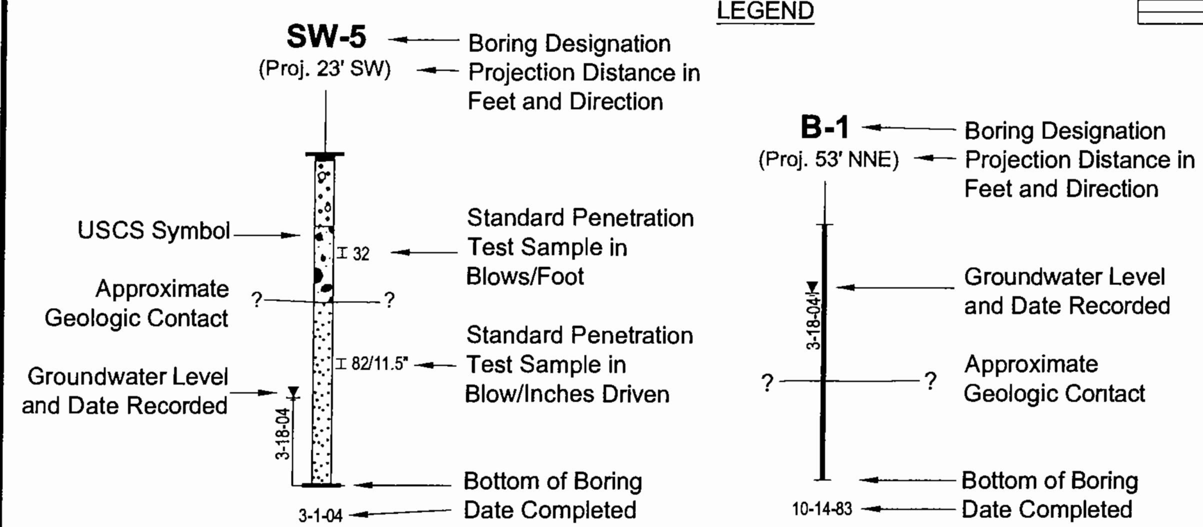

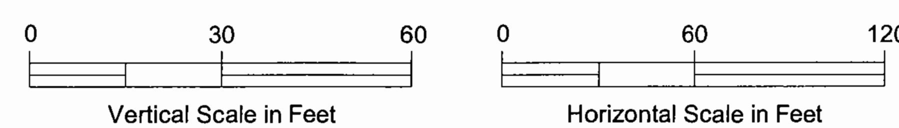

Vertical Exaggeration = 2X

NOTES

1. This figure is adapted from drawings provided by Exeltech, received 3-10-04.
2. Vertical datum: NAVD88.
3. This subsurface profile is generalized from materials observed in the soil borings. Variations may exist between the profile and actual conditions.

UNIFIED SOIL CLASSIFICATION SYSTEM
(From ASTM D 2488-93 & 2487-93)

GW	SM
GP	SC
GW-GM	CL
GP-GM	ML
GM	OL
GC	CH
SW	MH
SP	OH
SW-SM	PT
SP-SM	

Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

GENERALIZED SUBSURFACE PROFILE

July 2006 21-1-09948-003

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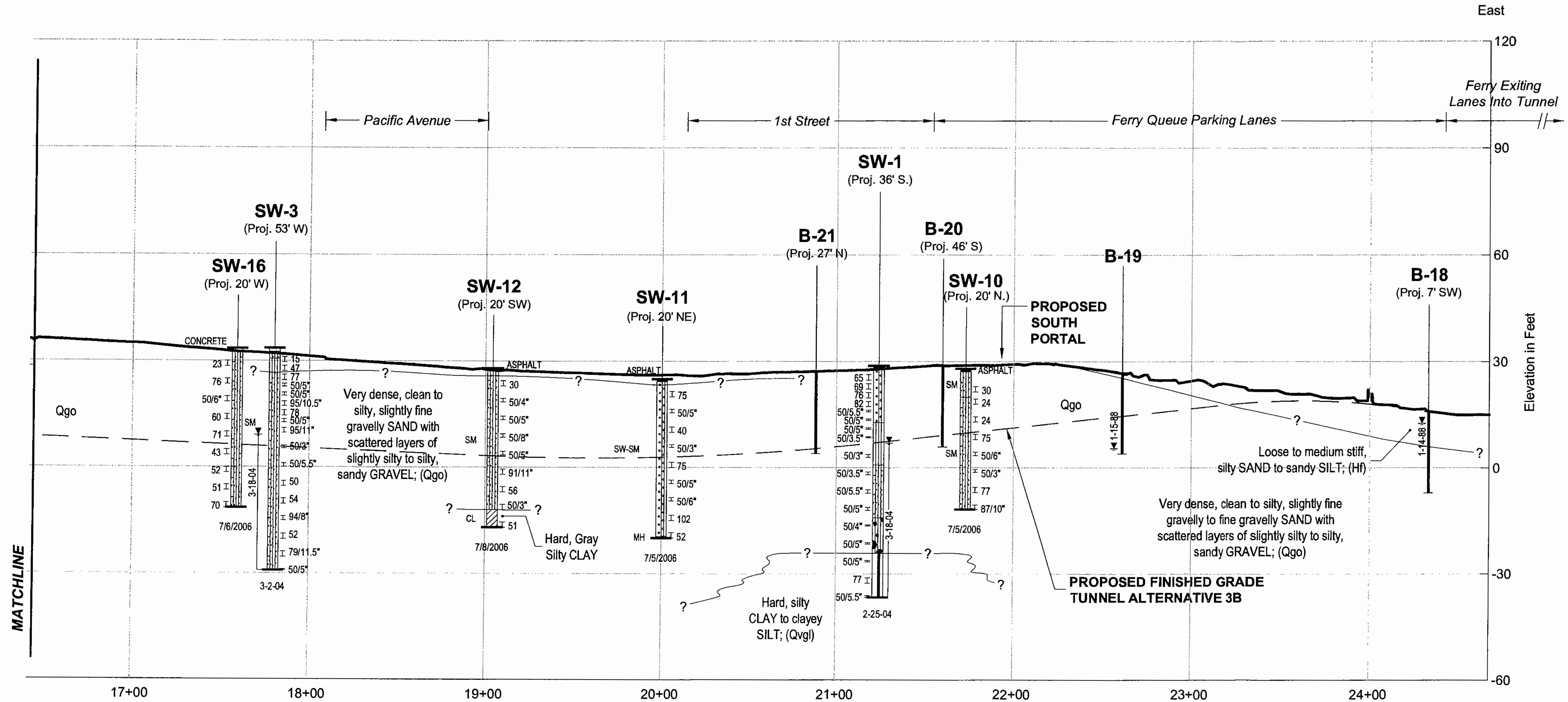
FIG. 5
Sheet 1 of 2

File: J:\211\09948-003\21-1-09948-003 fig 5 (07-06).dwg Date: 07-18-2006 Author: draftemp



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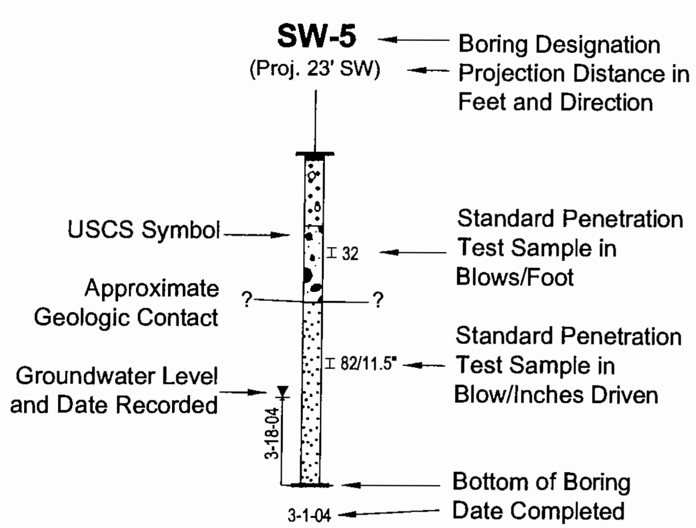

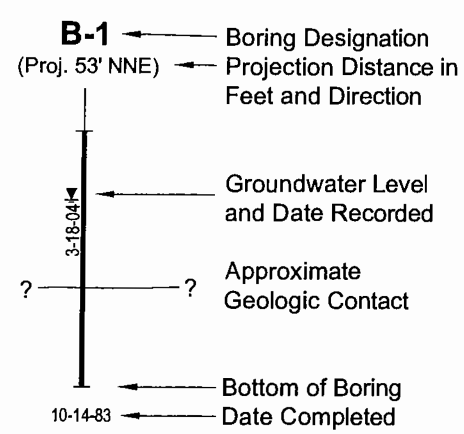

0 30 60
Vertical Scale in Feet

0 60 120
Horizontal Scale in Feet

Vertical Exaggeration = 2X

NOTES

1. This figure is adapted from drawings provided by Exeltech, received 3-10-04.
2. Vertical datum: NAVD88.
3. This subsurface profile is generalized from materials observed in the soil borings. Variations may exist between the profile and actual conditions.

UNIFIED SOIL CLASSIFICATION SYSTEM
(From ASTM D 2488-93 & 2487-93)

GW			SM
GP			SC
GW-GM			CL
GP-GM			ML
GM			OL
GC			CH
SW			MH
SP			OH
SW-SM			PT
SP-SM			

Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

GENERALIZED SUBSURFACE PROFILE

July 2006 21-1-09948-003

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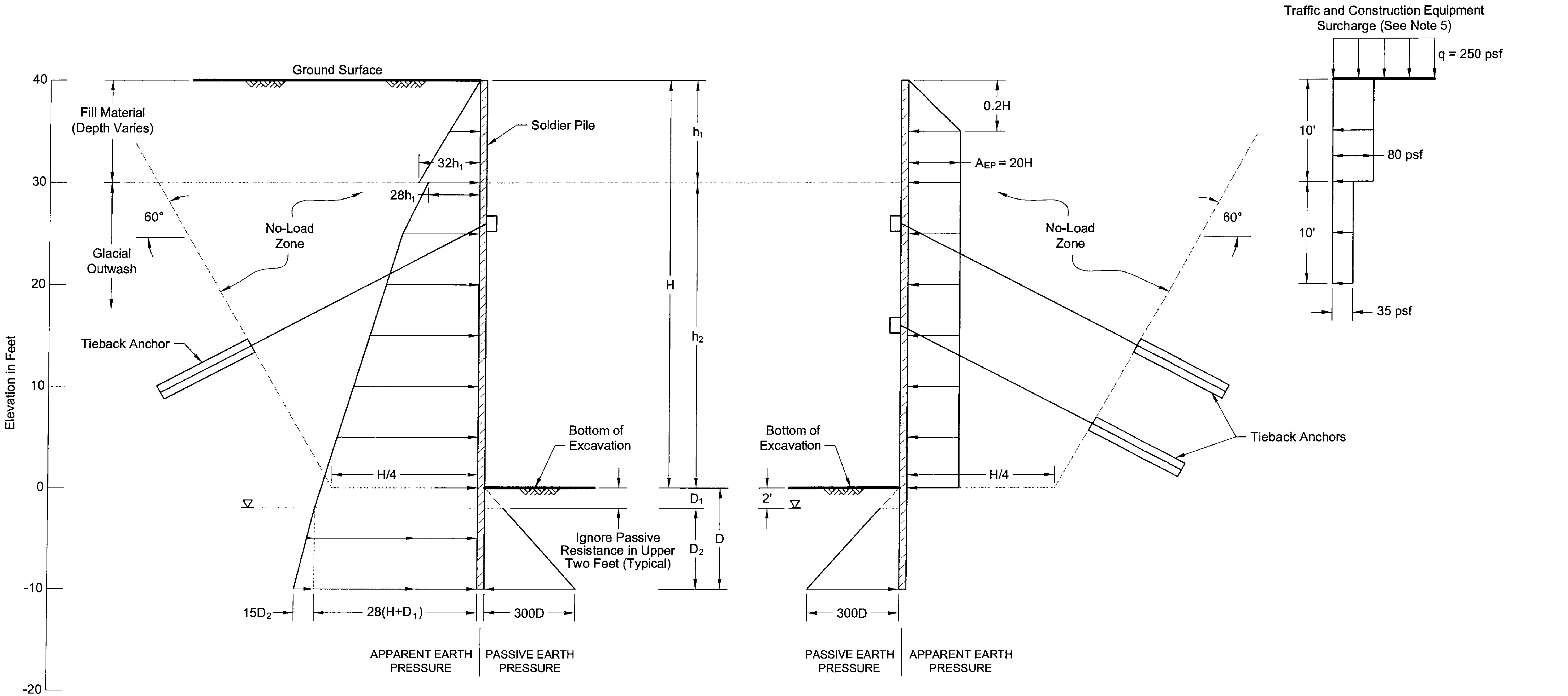
FIG. 5
Sheet 2 of 2

File: J:\211\09948-003\21-1-09948-003 fig 5 (07-06).dwg Date: 07-18-2006 Author: draftemp



B) Recommended Earth Pressures for Cantilevered and Single-Row, Braced or Tieback Walls

B) Recommended Earth Pressures for Multiple-Row, Braced or Tieback Walls

NOTES

1. Fill material thickness, h_1, varies along project alignment. See soil boring logs and tunnel profile for approximate elevations of geologic contacts along the alignment.
2. Locations and number of internal braces or tiebacks are for illustrative purposes only, not for design.
3. Earth pressures shown assume that internal braces or tiebacks are installed and prestressed prior to excavating more than 3 feet below the design brace/tieback level within 20 feet of soldier piles.
4. Use 50% of the above pressures for lagging design.
5. Lateral pressure is based on an assumed traffic surface surcharge of 250 psf acting over a limited influence area. More severe construction equipment loading requires special analysis. Refer to Figure 8 for additional lateral pressures due to adjacent buildings and other surcharge loads.
6. Above excavation level pressures should be assumed to act over soldier pile spacing. Below excavation level, passive pressures should be assumed to act over twice the soldier pile diameter (2B) or the soldier pile spacing, whichever is smaller.
7. D = Wall embedment below excavation level in feet should consider necessary vertical pile capacity and kickout resistance. Embedment for kickout resistance should be determined based on moment equilibrium below lowest brace or tieback level. D should be measured from the lowest point in the excavation. To determine the vertical pile capacity, the recommended ultimate end bearing and skin friction are 30 and 4 ksf, respectfully. The recommended resistance factor is 0.5 for both end bearing and skin friction.
8. The full pressures shown above should be used for structural analysis of piles for shear. Eighty percent of these pressures could be used for structural analysis for bending. Internal braces and ties should be prestressed as necessary to minimize wall movements.
9. It is assumed that the site is dewatered prior to and during construction so that hydrostatic pressures do not act on the walls.
10. A_{EP} in Diagram B may be truncated at the bottom of the excavation (0.2H) if necessary.
11. Based on the AASHTO LRFD Bridge Design Specification (2005), the recommended load factor for active earth pressure is 1.5; and the recommended resistance factor for passive earth pressure is 0.45.

LEGEND

H	Depth of Excavation
∇	Assumed Groundwater Level During Construction (Requires Dewatering)
h_1	Excavation Height in Fill Material, (Ft.)
h_2	Excavation Height in Glacial Outwash, (Ft.)
D	Embedment Depth of Shoring Pile, (Ft.)
D_1	Embedment Depth Above Groundwater, (Ft.)
D_2	Embedment Depth Below Groundwater, (Ft.)
A_{EP}	Apparent Earth Pressure

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EARTH PRESSURES FOR TEMPORARY SHORING

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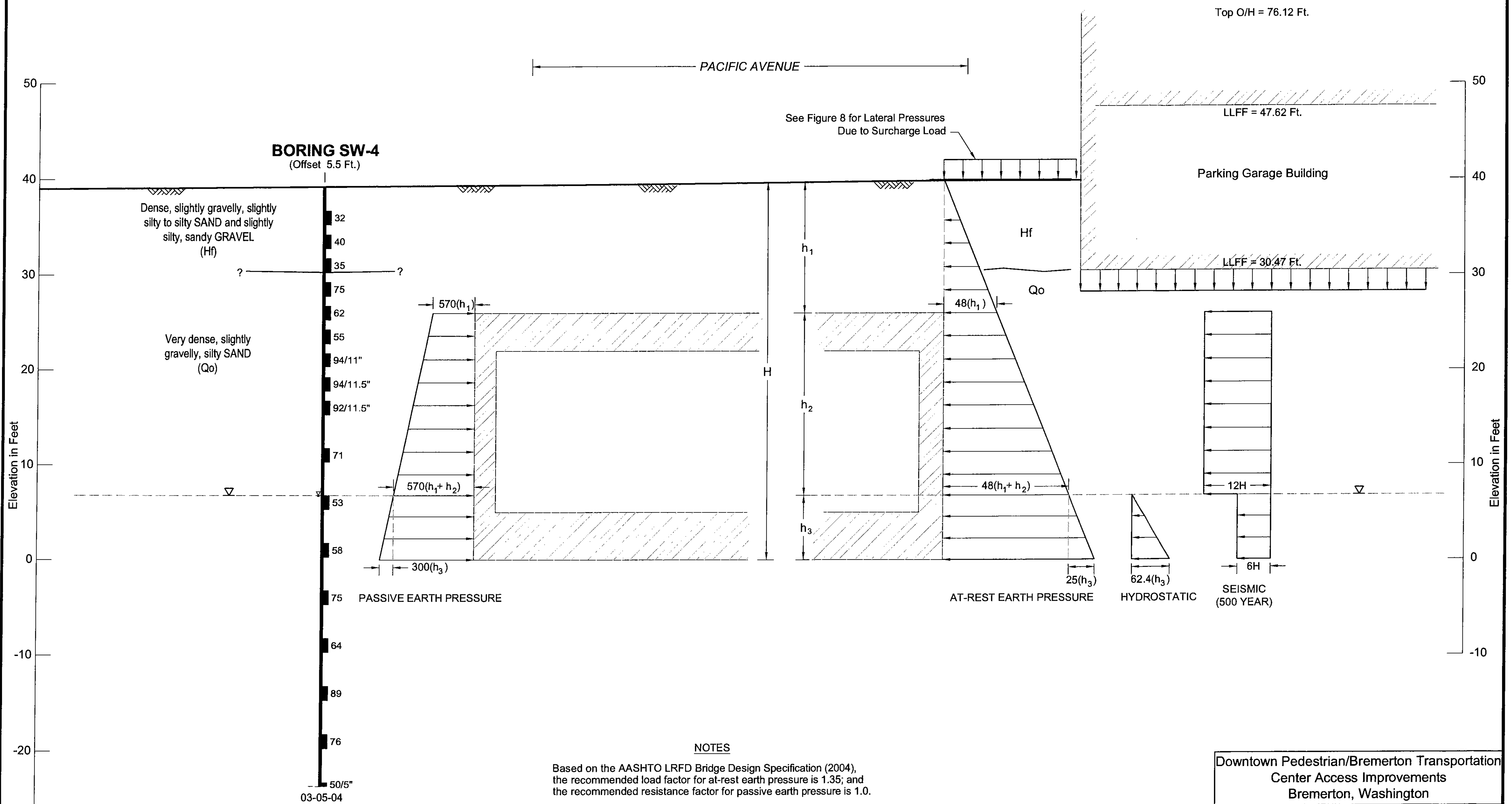
FIG. 6

File: J:\211\09948-003\21-1-09948-003 fig 6 (7-06).dwg Date: 07-18-2006 Author: draftemp



NOTES

Based on the AASHTO LRFD Bridge Design Specification (2004), the recommended load factor for at-rest earth pressure is 1.35; and the recommended resistance factor for passive earth pressure is 1.0.

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EARTH PRESSURES FOR PERMANENT TUNNEL STRUCTURE

July 2006 | 21-1-09948-003

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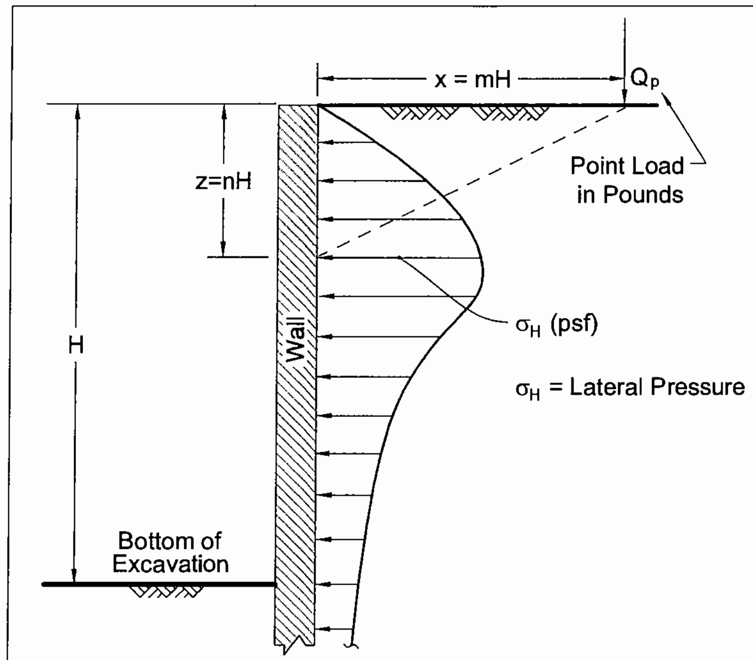
FIG. 7

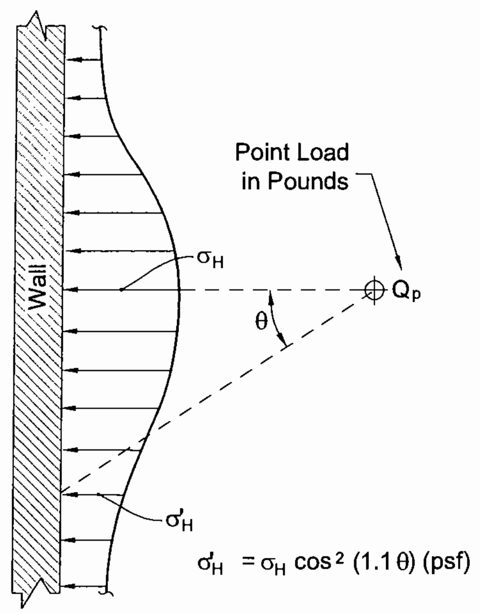
File: J:\211\09948-003\21-1-09948-004 fig 7 (7-06).dwg Date: 07-18-2006 Author: draftemp



ELEVATION VIEW

For $m \le 0.4$: $\sigma_H = 0.28 \dfrac{Q_p}{H^2} \dfrac{n^2}{(0.16 + n^2)^3}$ (psf) (see Note 3)

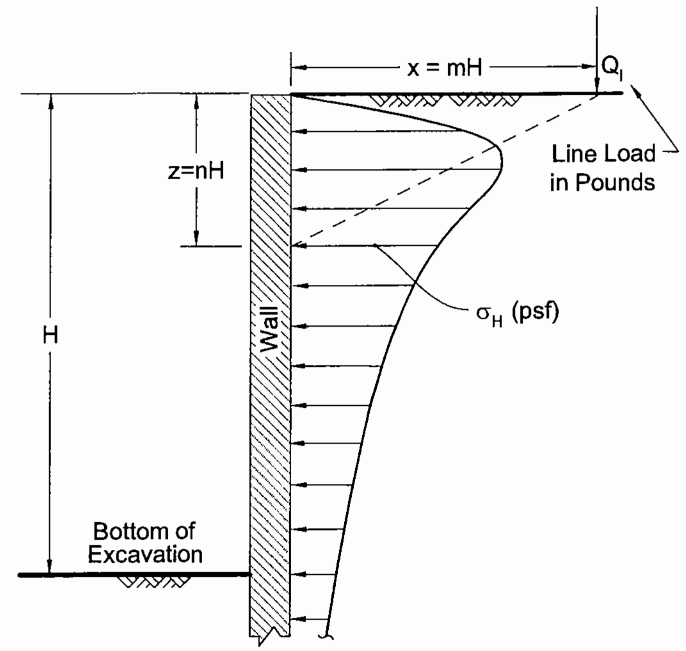
For $m > 0.4$: $\sigma_H = 1.77 \dfrac{Q_p}{H^2} \dfrac{m^2\, n^2}{(m^2 + n^2)^3}$ (psf)



PLAN VIEW

A) LATERAL PRESSURE DUE TO POINT LOAD i.e. SMALL ISOLATED FOOTING OR WHEEL LOAD

(NAVFAC DM 7.2, 1986)



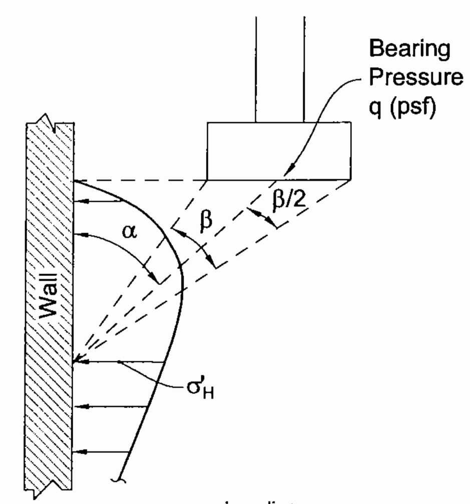
ELEVATION VIEW

For $m \le 0.4$: $\sigma_H = 0.20 \dfrac{Q_l}{H} \dfrac{n}{(0.16 + n^2)^2}$ (psf) (see Note 3)

For $m > 0.4$: $\sigma_H = 1.28 \dfrac{Q_l}{H} \dfrac{m^2\, n}{(m^2 + n^2)^2}$ (psf)

B) LATERAL PRESSURE DUE TO LINE LOAD i.e. NARROW CONTINUOUS FOOTING PARALLEL TO WALL

(NAVFAC DM 7.2, 1986)

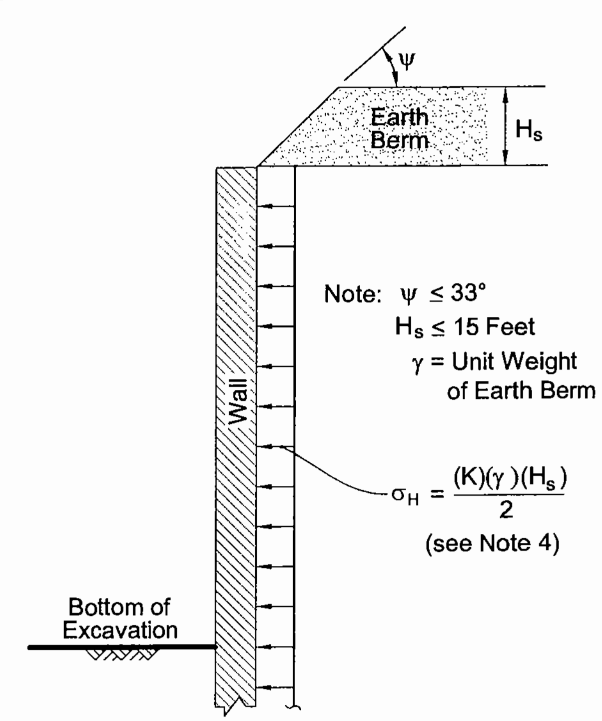


in radians

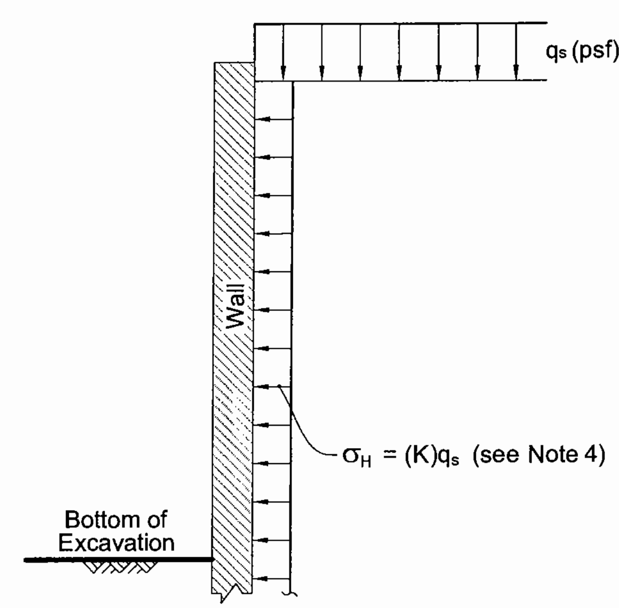
$\sigma_H = \dfrac{2q}{\pi}(\beta - \sin\beta\cos 2\alpha)$ (psf)

C) LATERAL PRESSURE DUE TO STRIP LOAD

(derived from Fang, *Foundation Engineering Handbook*, 1991)



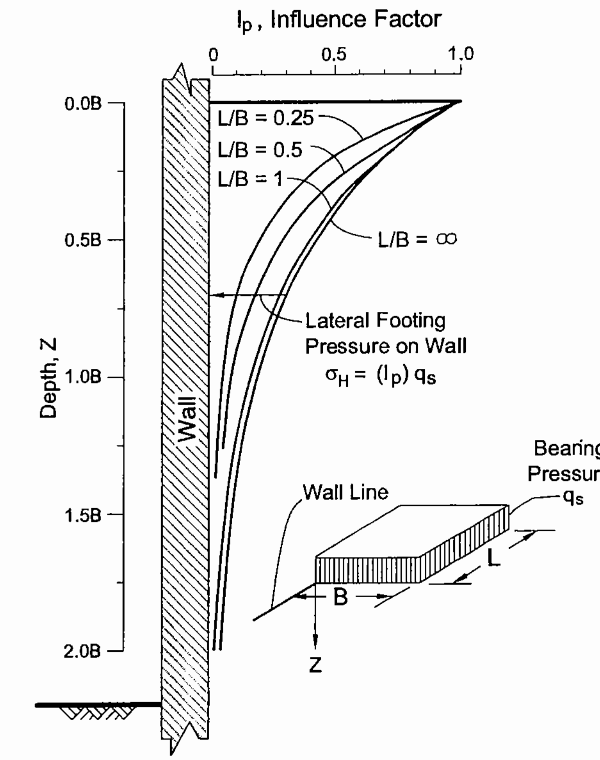
EARTH BERM



UNIFORM SURCHARGE

D) LATERAL PRESSURE DUE TO EARTH BERM OR UNIFORM SURCHARGE

(derived from Poulous and Davis, *Elastic Solutions for Soil and Rock Mechanics*, 1974; and Terzaghi and Peck, *Soil Mechanics in Engineering Practice*, 1967)



E) LATERAL PRESSURE DUE TO ADJACENT FOOTING

(derived from NAVFAC DM 7.2, 1986; and Sandhu, *Earth Pressure on Walls Due to Surcharge*, 1974)

NOTES

1. Figures are not drawn to scale.
2. Applicable surcharge pressures should be added to appropriate permanent wall lateral earth and water pressure.
3. If point or line loads are close to the back of the wall such that $m \le 0.4$, it may be more appropriate to model the actual load distribution (i.e., Figure E) or use more rigorous analysis methods.
4. See text for recommended K values.

Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

RECOMMENDED SURCHARGE LOADING FOR TEMPORARY AND PERMANENT WALLS

July 2006 | 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 8

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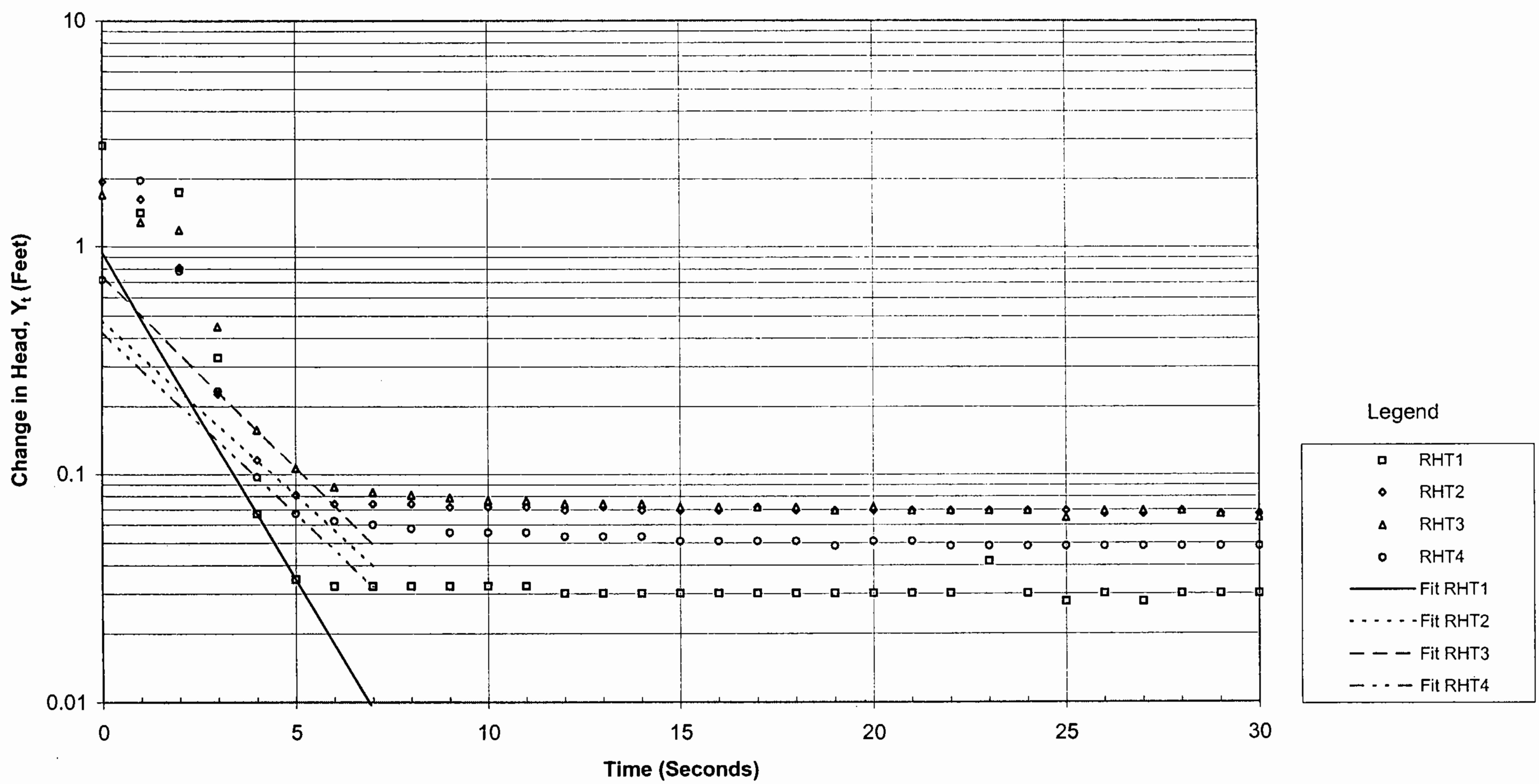

Notes:
1. RHT1 denotes type of slug test, i.e., Rising Head Test (RHT). Multiple tests are designated by the digit placed at the end.
2. In accordance with the procedures developed by Bouwer & Rice (1976), "Fit" represents a linear approximation of the data used for calculation of soil hydraulic conductivity.

Downtown Pedestrian/Bremerton Transportation Center Access Improvements

RISING HEAD SLUG TESTS
WELL SW-2

March 2006 21-1-09948-003

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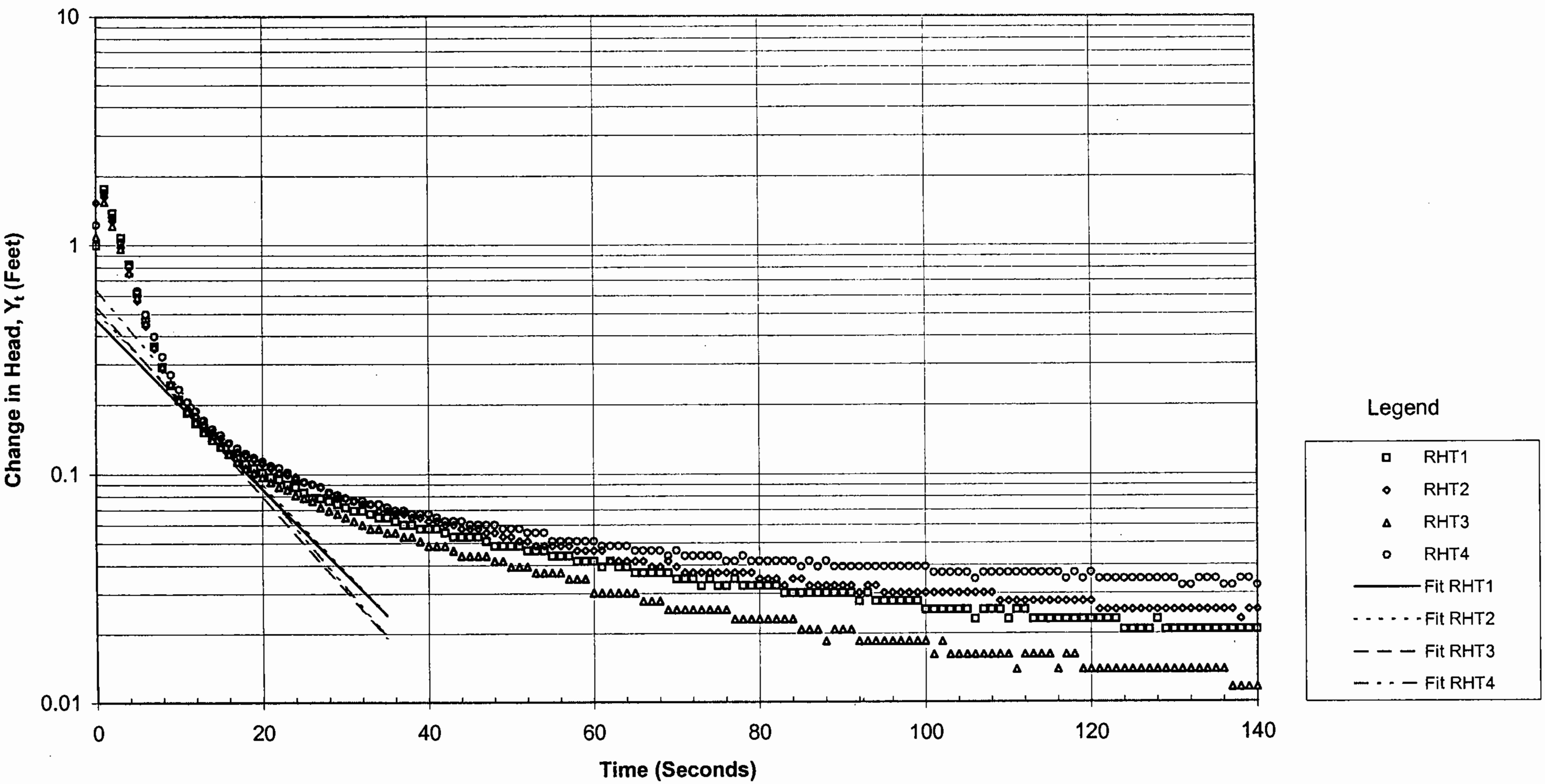
FIG. 9

FIG. 9



Notes:

1. RHT1 denotes type of slug test, i.e., Rising Head Test (RHT). Multiple tests are designated by the digit placed at the end.
2. In accordance with the procedures developed by Bouwer & Rice (1976), "Fit" represents a linear approximation of the data used for calculation of soil hydraulic conductivity.

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RISING HEAD SLUG TESTS WELL SW-3

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FIG. 10

FIG. 10

APPENDIX A

SUBSURFACE EXPLORATIONS

APPENDIX A

SUBSURFACE EXPLORATIONS

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LIST OF FIGURES

LIST OF FIGURES (cont.)

Figure No.

APPENDIX A

SUBSURFACE EXPLORATIONS

A.1 INTRODUCTION

Six soil borings, designated SW-1 through SW-6, were drilled along the proposed Downtown Pedestrian/Bremerton Transportation Center Access Improvements (DP/BTC) alignment between February 25 and March 5, 2004. The locations of these borings are shown in the Site and Exploration Plan, Figure 2, and the Generalized Subsurface Profile, Figure 5. These borings ranged in depth from approximately 51 to 71 feet. Monitoring wells consisting of 2-inch-diameter plastic casing with 10- to 20-foot screened sections were installed in each boring.

Ten additional borings, designated SW-10 through SW-19, were drilled between July 5 and 8, 2006. The approximate locations are shown in Figures 2 and 5. Depths of these recent borings ranged from 40 to 50 feet. No monitoring wells were installed.

Subsurface information from previous explorations along the project alignment was evaluated to supplement the information derived from soil borings SW-1 through SW-19. Fourteen soil borings from three previous projects were evaluated and are included in this appendix. These previous projects were:

- SR-304 Signing Project – M.P. 2.91 Vicinity, Washington State Department of Transportation (WSDOT), February 2002
- Bremerton Wastewater Improvements, CH2M Hill, January 1988
- Proposed Sheet Metal Storage Building, PSNS, Converse Consultants, October 1983

The locations of these previous borings are shown in Figures 2 and 5. Logs of these borings are included as Figures A-8 through A-21.

A.2 DRILLING PROCEDURES

Holt Drilling, Inc. (now Boart-Longyear) provided a Mobile (Mobile) B-59 truck-mounted drill rig equipped with conventional hollow-stem auger drilling equipment to drill the 19 recent borings. Cuttings from the drill action were collected in steel drums and removed from the site by the drilling contractor. After the drilling and sampling were completed, a 2-inch outside-diameter (O.D.) observation well was installed in borings SW-1 through SW-8. Details of the well installations are shown in the boring logs.

A.3 SOIL SAMPLING

Standard Penetration Test (SPT) sampling was generally conducted at 2.5-foot intervals to a depth of 20 feet and at 5-foot intervals thereafter, as shown in the boring logs. Representative soil samples were obtained by a split-spoon sampler (sometimes known as a split-barrel sampler) used in conjunction with a SPT. The field representative visually classified the samples, compiled a detailed field log of each boring, and returned the samples to our laboratory for further analysis and testing. The Unified Soil Classification System (USCS), as described in Figure A-1, was used to classify the soils encountered in the soil borings.

During drilling, soil samples were field screened by the field engineer for potential contamination. The samples were checked using a photoionization detector (PID) as well as olfactory screening. The PID device is passed over the sampler immediately after opening to screen for the presence of volatile organic compounds (VOCs). If a reading above 2 parts per million (ppm) (our threshold value) was recorded, additional field screening was performed on the sample to determine if the reading was due to contamination, organics, or proximity to airborne sources such as exhaust. Based on the results of our field screening, four soil samples from borings SW-3 and SW-4 exhibited characteristics of contamination and were sent to an outside lab, OnSite Environmental, Inc. (OSE), for identification analysis. Cuttings from portions of borings SW-3 and SW-4 were temporarily stored in a steel drum on City of Bremerton property and subsequently were disposed of by Holt Drilling, Inc.

To obtain a representative soil sample, SPTs were performed in general accordance with the American Society for Testing and Materials (ASTM) D 1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils. In the SPT, a 2-inch O.D., 1.375-inch inside-diameter (I.D.), split-spoon sampler is driven with a 140-pound hammer falling freely through a height of 30 inches. The number of blows required to achieve each of three 6-inch increments of sampler penetration is recorded. The number of blows required to cause the last 12 inches of penetration is termed the Standard Penetration Resistance (N-value). When penetration resistances exceeded 50 to 100 blows for 6 inches or less of penetration, the test was generally terminated, and the number of blows was recorded along with the penetration distance.

A.4 REFERENCES

American Society for Testing and Materials (ASTM) International, 2002, Annual book of standards: West Conshohocken, Pa., American Society for Testing and Materials, Construction, v. 4.08, Soil and Rock (I): D 420-D 4914.

CH2M Hill, 1988, Bremerton wastewater improvements project: Bellevue, Wash., CH2M Hill.

Converse Consultants, 1983, Proposed sheet metal storage building: Converse Consultants.

Washington State Department of Transportation, 2002, SR-304 signing project, MP 2.91 Vic.: Olympia, Wash., Washington State Department of Transportation, job no. QE-2223.

Shannon & Wilson, Inc. (S&W), uses a soil classification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following page. Soil descriptions are based on visual-manual procedures (ASTM D 2488-93) unless otherwise noted.

S&W CLASSIFICATION OF SOIL CONSTITUENTS

- MAJOR constituents compose more than 50 percent, by weight, of the soil. Major consituents are capitalized (i.e., SAND).
- Minor constituents compose 12 to 50 percent of the soil and precede the major constituents (i.e., silty SAND). Minor constituents preceded by "slightly" compose 5 to 12 percent of the soil (i.e., slightly silty SAND).
- Trace constituents compose 0 to 5 percent of the soil (i.e., slightly silty SAND, trace of gravel).

MOISTURE CONTENT DEFINITIONS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

ABBREVIATIONS

ATD	At Time of Drilling
Elev.	Elevation
ft	feet
FeO	Iron Oxide
MgO	Magnesium Oxide
HSA	Hollow Stem Auger
ID	Inside Diameter
in	inches
lbs	pounds
Mon.	Monument cover
N	Blows for last two 6-inch increments
NA	Not applicable or not available
NP	Non plastic
OD	Outside diameter
OVA	Organic vapor analyzer
PID	Photo-ionization detector
ppm	parts per million
PVC	Polyvinyl Chloride
SS	Split spoon sampler
SPT	Standard penetration test
USC	Unified soil classification
WLI	Water level indicator

GRAIN SIZE DEFINITION

DESCRIPTION	SIEVE NUMBER AND/OR SIZE
FINES	< #200 (0.08 mm)
SAND*	
- Fine	#200 to #40 (0.08 to 0.4 mm)
- Medium	#40 to #10 (0.4 to 2 mm)
- Coarse	#10 to #4 (2 to 5 mm)
GRAVEL*	
- Fine	#4 to 3/4 inch (5 to 19 mm)
- Coarse	3/4 to 3 inches (19 to 76 mm)
COBBLES	3 to 12 inches (76 to 305 mm)
BOULDERS	> 12 inches (305 mm)

* Unless otherwise noted, sand and gravel, when present, range from fine to coarse in grain size.

RELATIVE DENSITY / CONSISTENCY

COARSE-GRAINED SOILS		FINE-GRAINED SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
0 - 4	Very loose	Under 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
Over 50	Very dense	15 - 30	Very stiff
		Over 30	Hard

WELL AND OTHER SYMBOLS

Bent. Cement Grout	Surface Cement Seal
Bentonite Grout	Asphalt or Cap
Bentonite Chips	Slough
Silica Sand	Bedrock
PVC Screen	
Vibrating Wire	

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Bremerton, Washington

SOIL CLASSIFICATION AND LOG KEY

July 2006 21-1-09948-003

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FIG. A-1
Sheet 1 of 2

BORING CLASS1 21-09948.GPJ SWNEW.GDT 7/18/06

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(From ASTM D 2487-98 & 2488-93)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL DESCRIPTION
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels *(less than 5% fines)*	GW		Well-graded gravels, gravels, gravel/sand mixtures, little or no fines
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines *(more than 12% fines)*	GM		Silty gravels, gravel-sand-silt mixtures
			GC		Clayey gravels, gravel-sand-clay mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean Sands *(less than 5% fines)*	SW		Well-graded sands, gravelly sands, little or no fines
			SP		Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines *(more than 12% fines)*	SM		Silty sands, sand-silt mixtures
			SC		Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL		Organic silts and organic silty clays of low plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH		Inorganic clays or medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH		Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTE: No. 4 size = 5 mm; No. 200 size = 0.075 mm

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/gravelly SAND)* indicate that the soil may fall into one of two possible basic groups.

Downtown Pedestrian/Bremerton
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SOIL CLASSIFICATION AND LOG KEY

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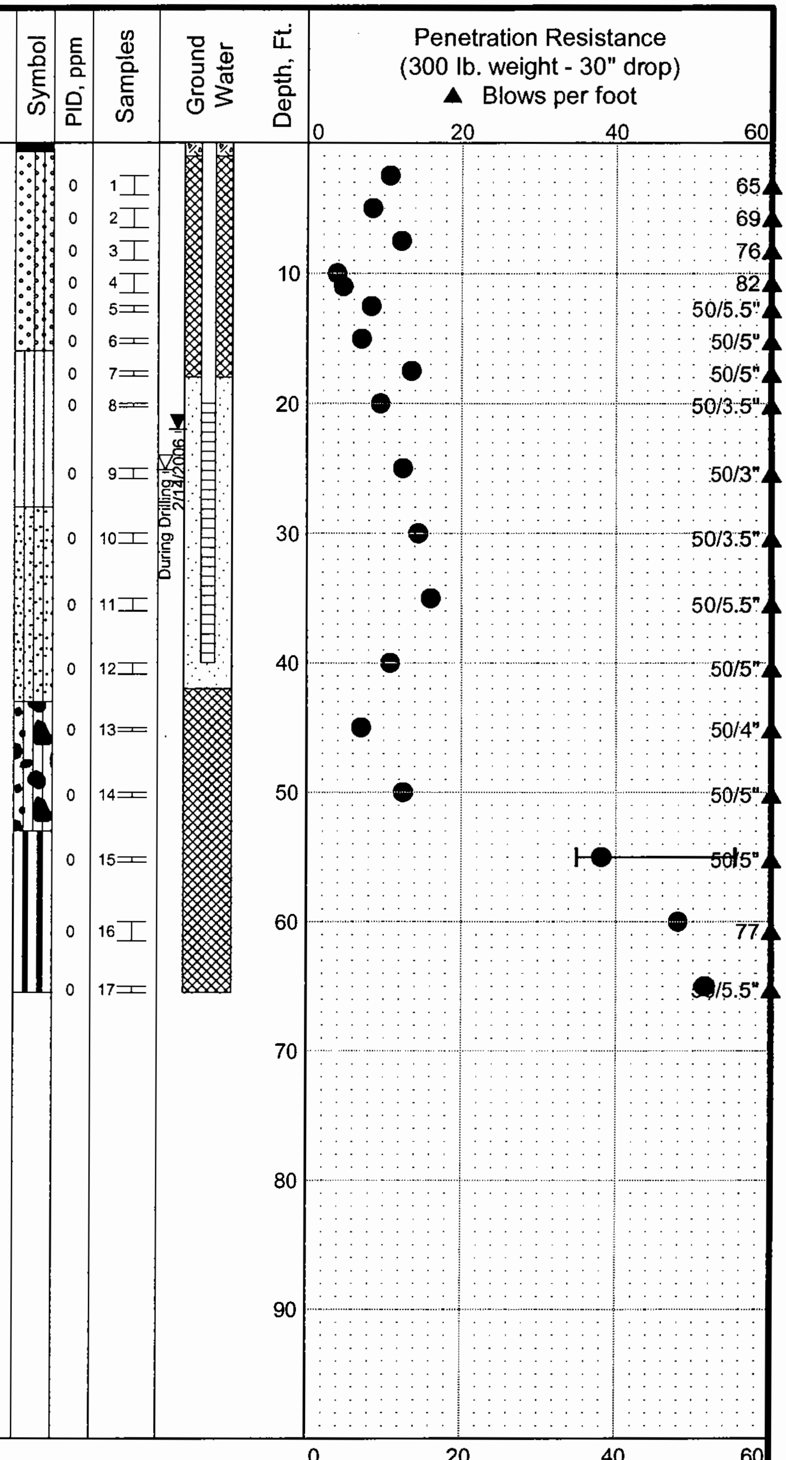
FIG. A-1
Sheet 2 of 2

BORING CLASS2 21-09948.GPJ SWNEW.GDT 7/18/06

SOIL DESCRIPTION Surface Elevation: Approx. 28.8 Ft.	Depth, Ft.
Asphalt (2 inches) and brick (6 inches).	0.7
Very dense, brown, slightly gravelly, slightly silty to silty SAND; moist; scattered layers of slightly silty, sandy gravel and clean sand; (Qgo) SW-SM/SM.	16.0
Very dense, brown, slightly fine gravelly, sandy SILT; moist turning to wet; (Qgo) ML.	28.0
Very dense, brown to gray, slightly fine gravelly to fine gravelly, silty SAND; wet; (Qgo) SM.	43.0
Very dense, brown, slightly sandy, silty GRAVEL; wet; granite cobble encountered at 50.2 feet; (Qgo) GM.	53.0
Hard, blue-gray, clayey SILT to silty CLAY, trace of fine sand and fine gravel; moist; (Qvgl) MH/CH.	65.5
BOTTOM OF HOLE COMPLETED 2/25/2004	



LEGEND

*	Sample Not Recovered
⌶	Standard Penetration Test
	Piezometer Screen and Sand Filter
	Bentonite-Cement Grout
	Bentonite Chips/Pellets
	Bentonite Grout
∇	Ground Water Level ATD
▼	Ground Water Level in Well

● % Water Content

Plastic Limit ⊢—●—⊣ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-1

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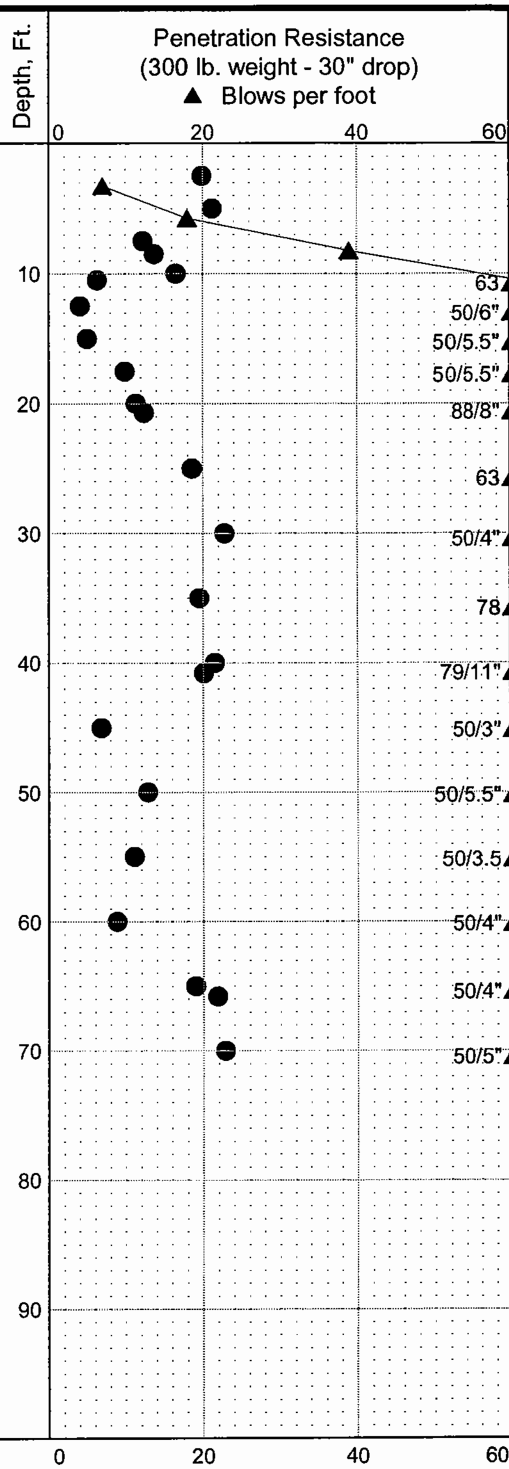
FIG. A-2

SOIL DESCRIPTION Surface Elevation: Approx. 22.3 Ft.	Depth, Ft.	PID, ppm	Samples
Asphalt.	0.7		
Loose to dense, reddish-brown to gray, slightly clayey to clayey, fine sandy SILT to silty, fine SAND, trace of fine gravel; moist; (Qf) ML/SM.	9.5	0 0 0	1 2 3
Very dense, brown, slightly silty, sandy GRAVEL; moist turning to wet; (Qgo) GW-GM. - 1-foot layer of slightly fine gravelly, silty fine sand at 11 feet	21.0	0 0 0 0 0	4 5 6 7 8
Very dense, brown to brown-gray, clean to slightly silty SAND, trace of fine gravel; wet; scattered lenses of brown, fine sandy silt; (Qgo) SP/SP-SM.	41.0	0 0 0 0.2	9 10 11 12
Very dense, brown, silty, fine SAND; moist; scattered fine gravel; (Qgo) SM.	44.0		
Very dense, gray, clean to slightly silty SAND; clean to slightly silty, fine gravelly SAND; and clean to slightly silty, sandy GRAVEL; wet; cobble encountered at 45.3 feet; (Qgo) SW-SM/SW/GW-GM/GW.	70.9	0 0 0 0 0 0	13 14 15 16 17 18

BOTTOM OF BORING
COMPLETED 2/26/2004

Ground Water: During Drilling 2/14/2006



LEGEND

- * Sample Not Recovered
- Ɪ Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- ∇ Ground Water Level ATD
- ▼ Ground Water Level in Well

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-2

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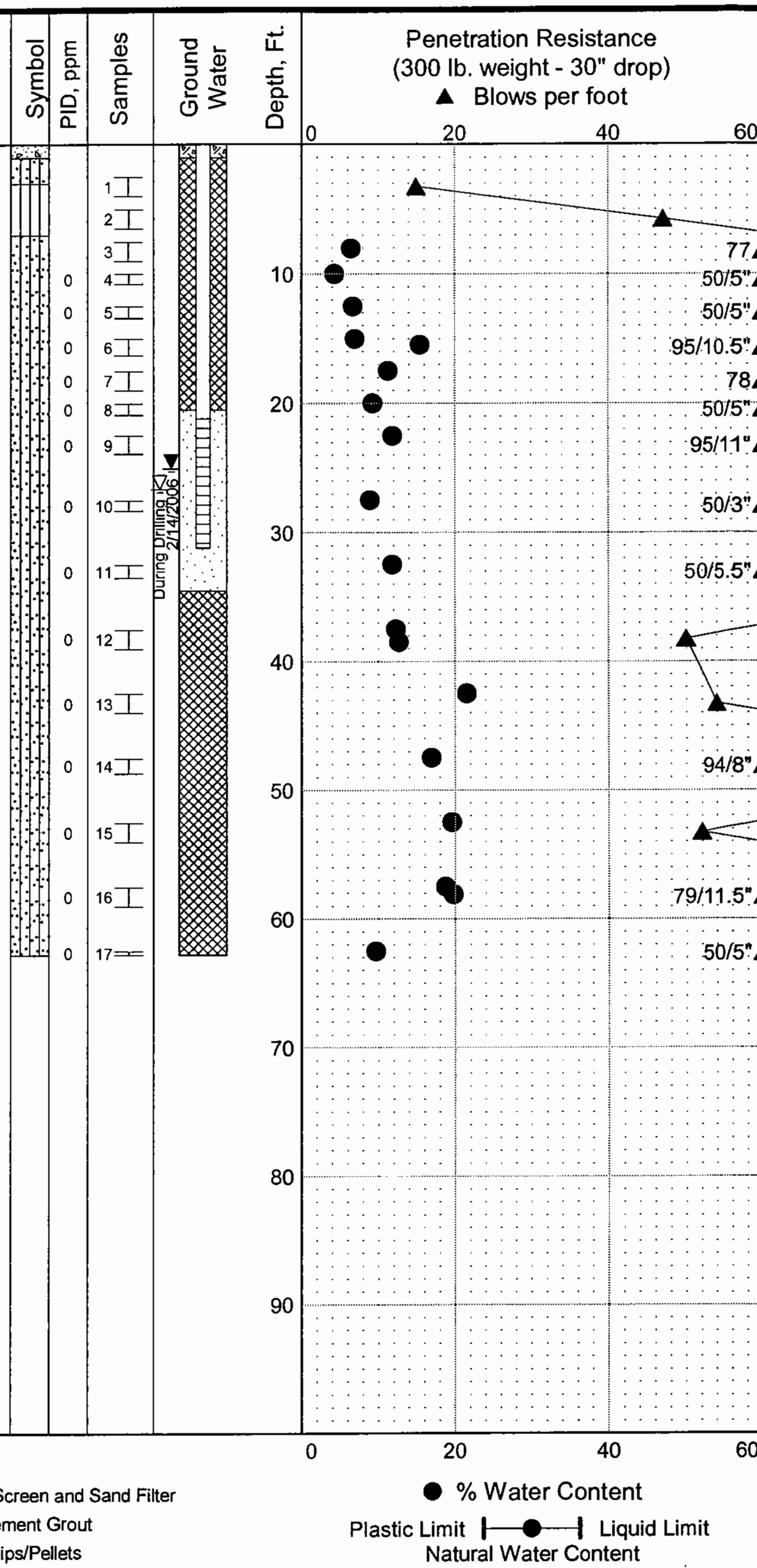
FIG. A-3

SOIL DESCRIPTION Surface Elevation: Approx. 33.6 Ft.	Depth, Ft.
Concrete.	1.0
Medium dense, yellowish-brown, silty, fine to medium SAND; moist; (Qf) SM. Note: Hydrocarbon odor detected in Sample S-1.	3.0
Medium dense to dense, yellowish-brown, trace to slightly gravelly, fine sandy SILT; moist; (Qf) ML/SM. Note: Hydrocarbon odor detected in Sample S-2.	7.0
Very dense, gray to gray-brown, slightly fine gravelly to fine gravelly, slightly silty to silty SAND with scattered layers including coarse gravel; moist turning to wet; (Qgo) SM/SP-SM. Note: Hydrocarbon odor detected in Sample S-3.	
BOTTOM OF BORING COMPLETED 3/2/2004	62.8



LEGEND

*	Sample Not Recovered
⌶	Standard Penetration Test
	Piezometer Screen and Sand Filter
	Bentonite-Cement Grout
	Bentonite Chips/Pellets
	Bentonite Grout
⊻	Ground Water Level ATD
▼	Ground Water Level in Well

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton
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LOG OF BORING SW-3

July 2006 21-1-09948-003

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FIG. A-4

MASTER_LOG2 21-09948.GPJ SHAN_WIL.GDT 7/18/06

Log: SMP Rev: SMP Typ: LKD

SOIL DESCRIPTION

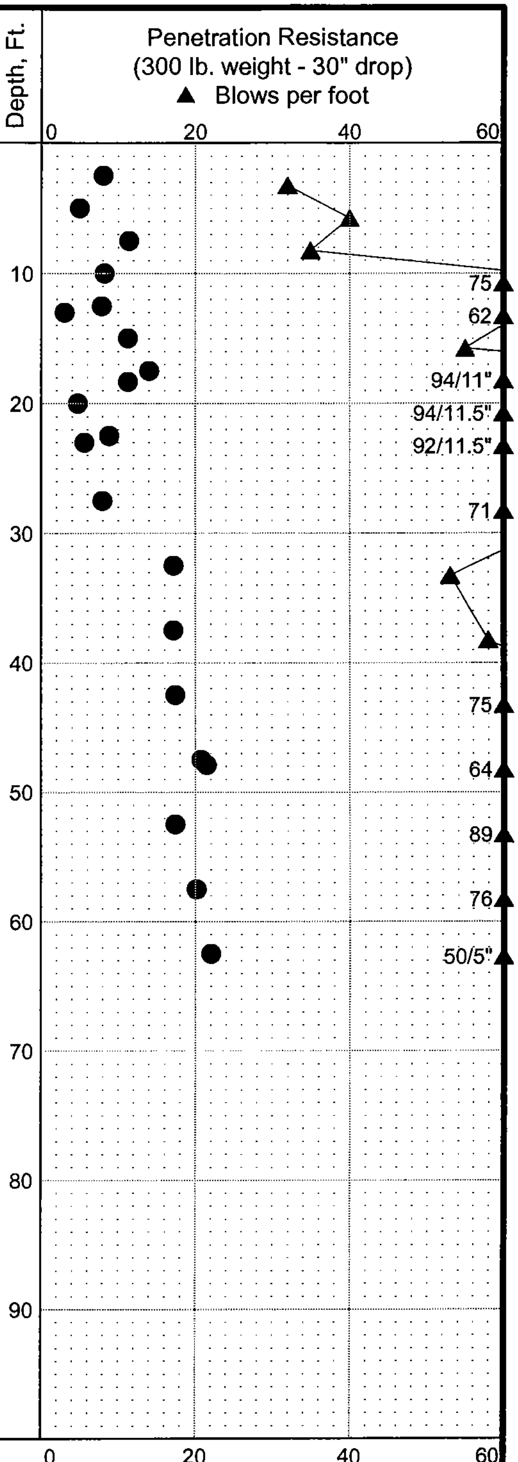
Surface Elevation: Approx. 39.0 Ft.

Depth, Ft.	Soil Description
0.2	Asphalt.
9.5	Dense, brown, slightly fine gravelly, slightly silty to silty, fine to medium SAND and brown to gray, slightly silty, sandy, fine GRAVEL; moist; trace of brick fragments from 4 to 5 feet depth; (Qf) SW-SM/SM/GW-GM. Note: Hydrocarbon odor detected in Samples S-1 and S-2.
62.9	Very dense, brown to gray-brown, slightly fine gravelly, silty, fine to medium SAND; moist turning to wet; (Qgo) SM. - 1-foot layer of silty, sandy, fine gravel at 22 feet

BOTTOM OF BORING
COMPLETED 3/5/2004

Samples	PID, ppm
1	4.2
2	10.1
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0

Ground Water: During Drilling 2/14/2006



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- ▽ Ground Water Level ATD
- ▼ Ground Water Level in Well

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton
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LOG OF BORING SW-4

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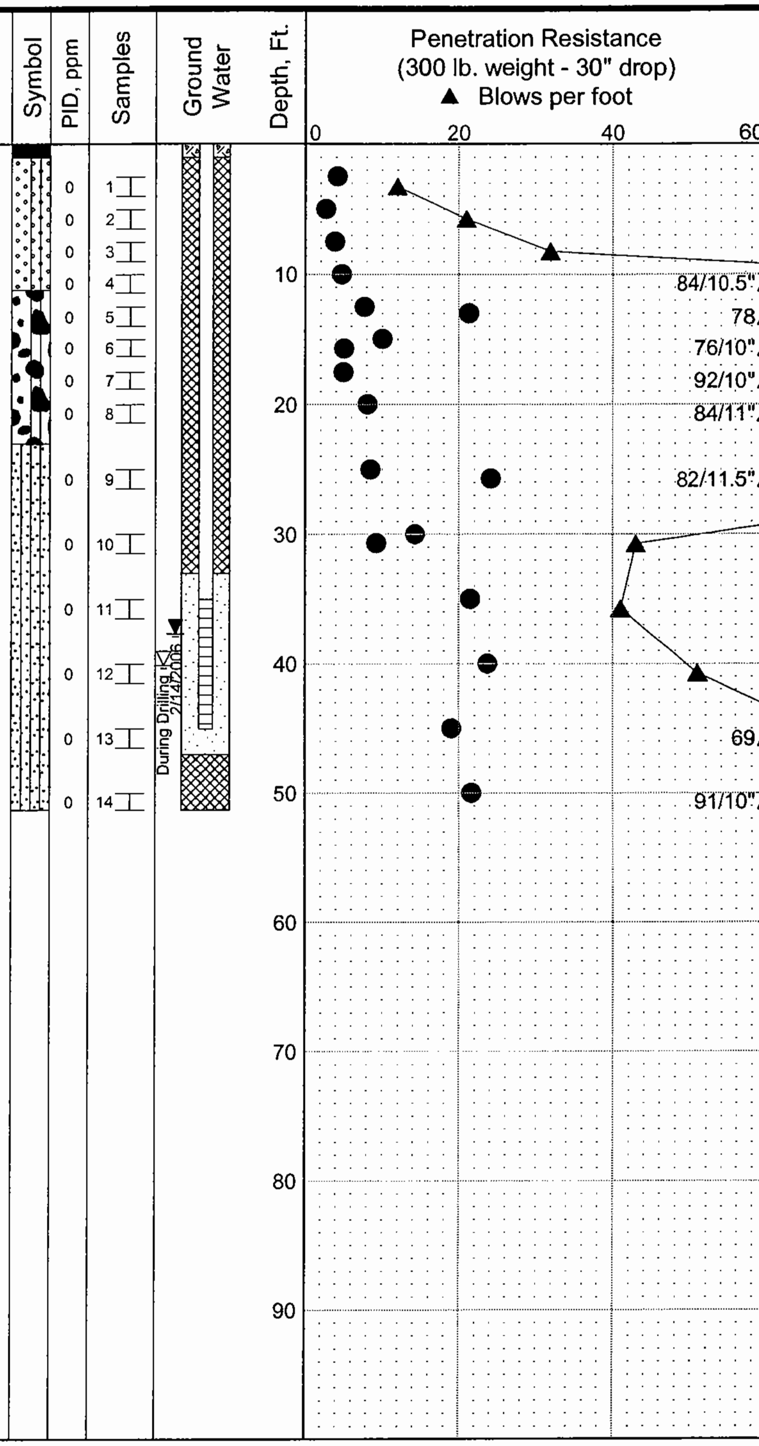
FIG. A-5

MASTER_LOG2 21-09948.GPJ SHAN WIL.GDT 7/18/06 Log: SMP Rev: SMP Typ: LKD

SOIL DESCRIPTION Surface Elevation: Approx. 44.3 Ft.	Depth, Ft.
12 inches of asphalt and concrete.	1.0
Medium dense to very dense, gray-brown, clean to slightly silty, fine gravelly SAND, trace of coarse gravel; moist; (Qf) SW-SM/SW.	11.2
Very dense, brown, slightly silty to silty, sandy GRAVEL; moist; (Qgo) GW-GM/GM/SW-SM/SM. - 1.5-foot layer of gray to reddish-brown, slightly sandy, silty gravel at 13 feet	23.0
Dense to very dense, yellow-brown to gray-brown, silty, fine to medium SAND, trace of fine gravel; moist turning to wet; (Qgo) SM. - 2-foot layer of reddish-brown, sandy SILT, trace of fine gravel at 25.5 feet	51.3

BOTTOM OF BORING
COMPLETED 3/1/2004



LEGEND

* Sample Not Recovered
Standard Penetration Test
Piezometer Screen and Sand Filter
Bentonite-Cement Grout
Bentonite Chips/Pellets
Bentonite Grout
Ground Water Level ATD
Ground Water Level in Well

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton
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LOG OF BORING SW-5

July 2006 21-1-09948-003

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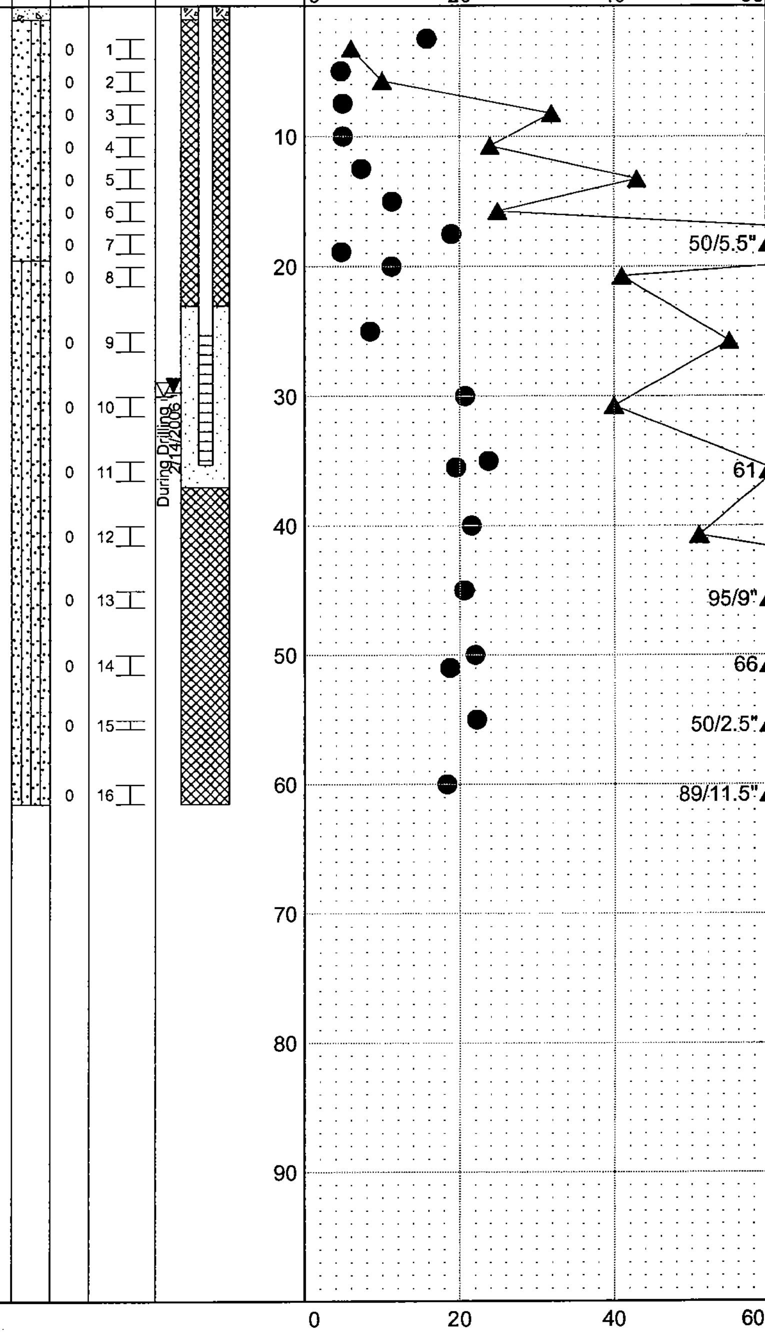
FIG. A-6

MASTER LOG2 21-09948.GPJ SHAN WIL.GDT 7/18/06 Log: SMP Rev: SMP Typ: LKD

SOIL DESCRIPTION Surface Elevation: Approx. 36.5 Ft.	Depth, Ft.
Concrete and asphalt.	1.0
Loose to very dense, gray-brown, slightly fine gravelly, slightly silty to silty, fine to medium SAND, trace of coarse sand; moist; (Qf) SP-SM/SM. - cobble encountered at 18.4 feet	19.5
Dense to very dense, brown, silty, fine SAND and gray-brown, silty, fine to medium SAND, trace of fine gravel; moist turning to wet; (Qgo) SM.	61.5
BOTTOM OF BORING COMPLETED 2/27/2004	

Samples	PID, ppm
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0

Symbol | Ground Water | Depth, Ft. | Penetration Resistance (300 lb. weight - 30" drop) ▲ Blows per foot



Log: SMP Rev: SMP Typ: LKD

LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-6

July 2006 21-1-09948-003

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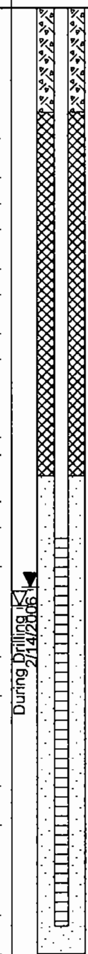
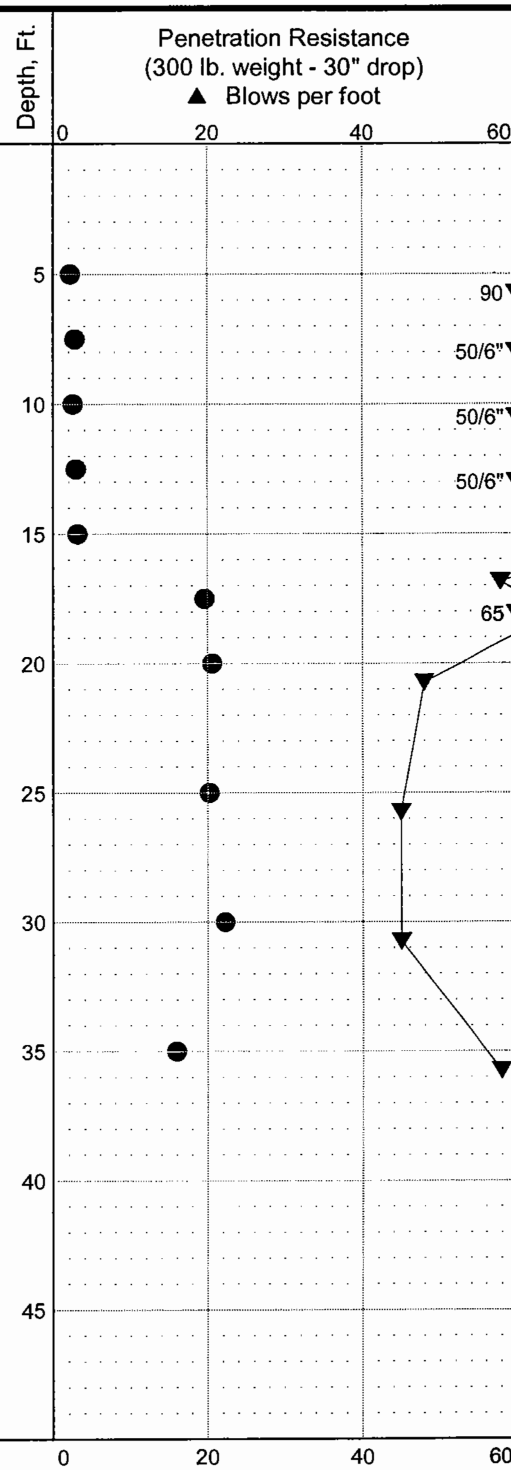
FIG. A-7

MASTER_LOG2 21-09948.GPJ SHAN_WIL.GDT 7/18/06

SOIL DESCRIPTION Surface Elevation: Approx. 29.0 Ft.	Depth, Ft.	PID, ppm	Samples
Asphalt.	0.8		
Concrete.	1.6		
Medium dense to dense (inferred from drill action), brown, trace to slightly silty, sandy GRAVEL; moist; (Fill) (Qf) GW-GM .	4.0	0	1
Very dense, brown, trace to slightly silty, slightly gravelly to gravelly SAND; moist; (Qgo) SW-SM.		0	2
		0	3
		0	4
Dense to very dense, brown to gray, slightly silty, fine to medium SAND; moist (wet at 22 feet); (Qgo) SW-SM.	17.0	0	5
		0	6
		0	7
		0	8
		0	9
		0	10
BOTTOM OF BORING COMPLETED 9/10/2004	36.5		

Ground Water





LEGEND

- * Sample Not Recovered
- 3" O.D. Split Spoon Sample
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well

● % Water Content

Plastic Limit ●— Liquid Limit

Natural Water Content

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-7

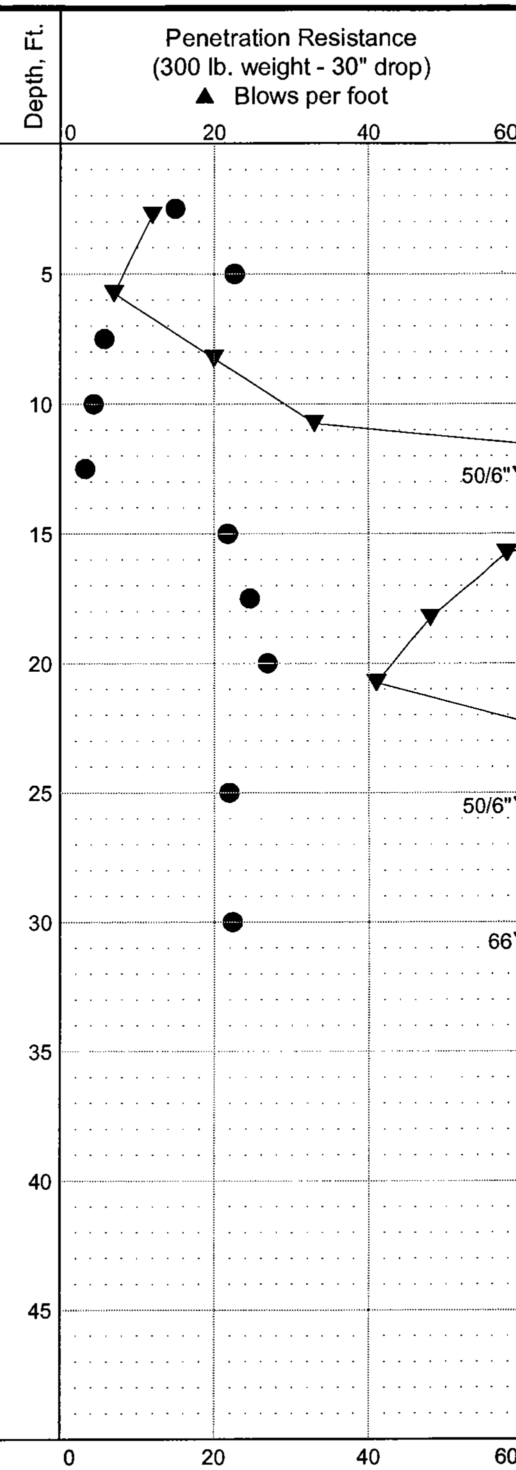
July 2006 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8

MASTER LOG2 21-09948.GPJ SHAN WIL.GDT 7/18/06 Log: JCD Rev: MWP Typ: LKD

SOIL DESCRIPTION Surface Elevation: Approx. 23.0 Ft.	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water
Asphalt.	0.5				
Loose to medium dense, brown to gray, slightly gravelly, silty SAND to sandy SILT; moist; occasional organics and wood debris; (Qf) SM/ML.	7.0		0 0	1 2	
Medium dense to very dense, brown, trace to slightly silty, slightly gravelly to gravelly SAND; moist; (Qgo) SW-SM.	14.0		0 0 0	3 4 5	
Very dense, brown, slightly silty SAND; moist; (wet at 16 feet); (Qgo) SW-SM.	17.0		0	6	During Drilling 2/14/2006
Dense to very dense, brown, trace to slightly silty, fine to medium SAND; moist to wet; (Qgo) SW-SM.	31.5		0 0 0 0	7 8 9 10	
BOTTOM OF BORING COMPLETED 9/10/2004					



LEGEND

- * Sample Not Recovered
- 3" O.D. Split Spoon Sample
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level ATD
- Ground Water Level in Well

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-8

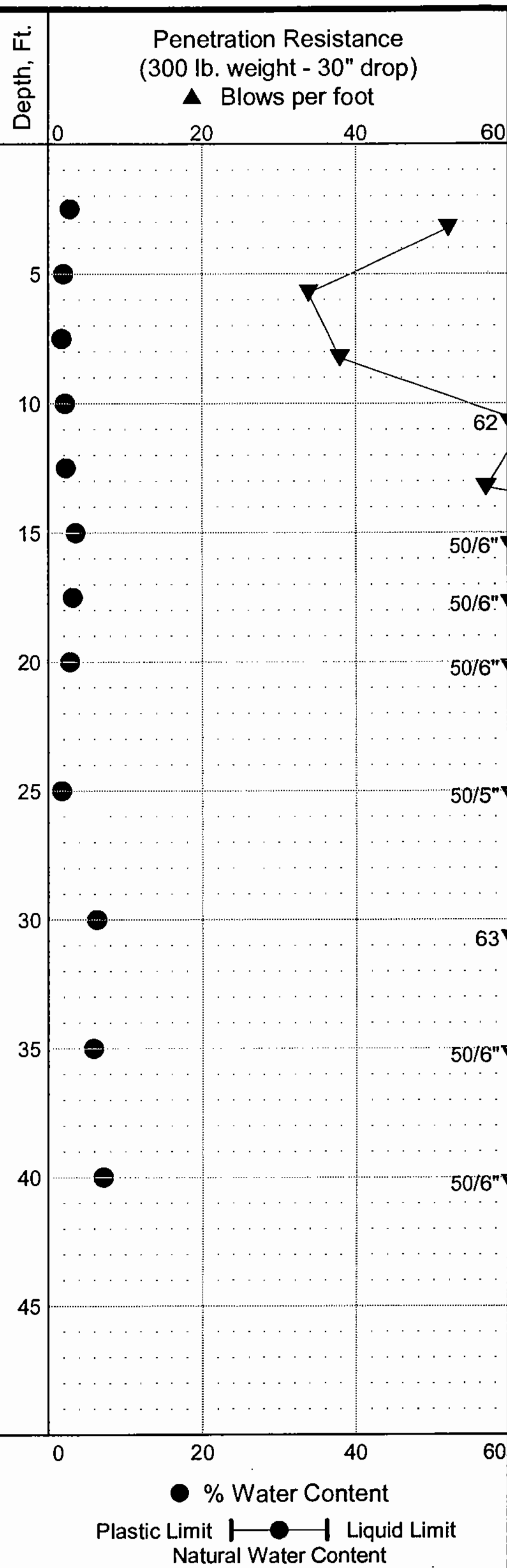
July 2006 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-9

MASTER_LOG2 21-09948.GPJ SHAN_WIL.GDT 7/18/06 Log: JCD Rev: MWP Typ: LKD

SOIL DESCRIPTION Surface Elevation: Approx. 50.5 Ft.	Depth, Ft.	Symbol	PID, ppm	Samples	Ground Water
Asphalt.	0.3				
Concrete.	1.0				
Dense to very dense, brown, trace to slightly silty, slightly gravelly to gravelly SAND; moist; (Qgo) SW-SM.			0 0 0 0 0 0 0 0 0	1 2 3 4 5 6 7 8 9	None Encountered During Drilling
Very dense, brown, trace to slightly silty, fine to medium SAND; moist; (Qgo) SW-SM.	27.0		0	10	
Very dense, brown, trace to slightly silty, slightly gravelly to gravelly SAND; moist; (Qgo) SW-SM.	33.0		0 0	11 12	
BOTTOM OF BORING COMPLETED 9/10/2004	40.5				



LEGEND

* Sample Not Recovered

3" O.D. Split Spoon Sample

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-9

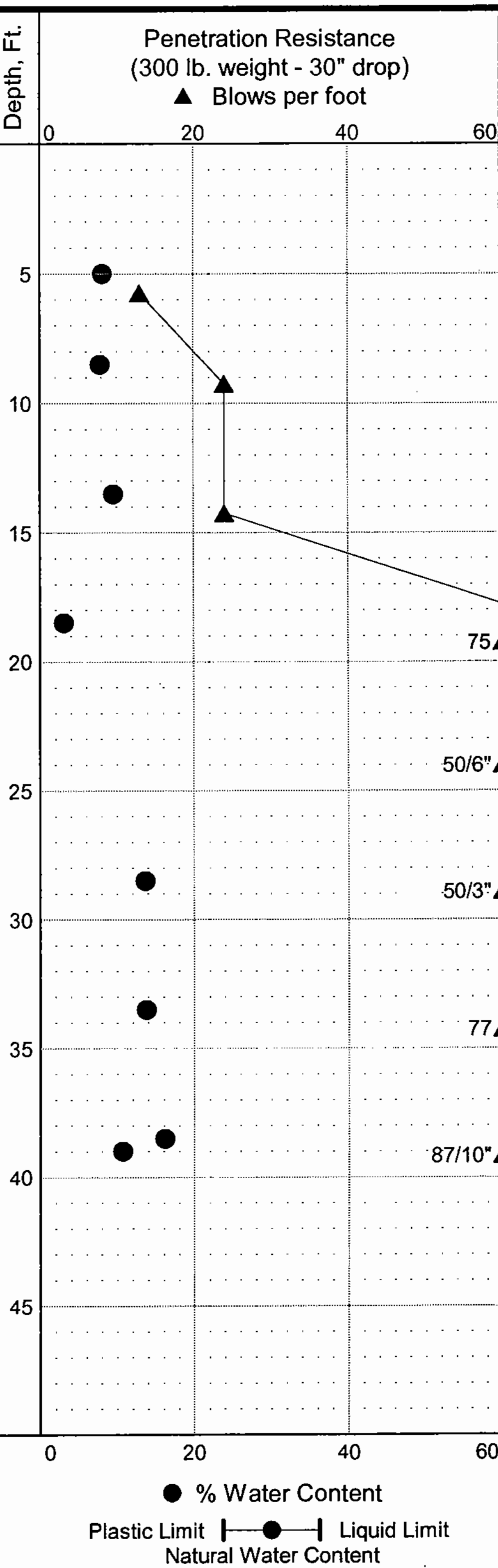
July 2006 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-10

MASTER LOG2 21-09948.GPJ SHAN WIL.GDT 7/18/06 Log: JCD Rev: MWP Typ: LKD

SOIL DESCRIPTION Surface Elevation: Approx. 28.0 Ft.	Depth, Ft.	Samples	Ground Water
Asphalt pavement and base course.	0.9		
Medium dense, brown, silty, gravelly SAND; moist; scattered brick fragments; (Fill) SM.	8.0	1	
Medium dense to very dense, slightly gravelly, silty SAND; occasional layers of gravelly sand; moist to wet at 23 feet; (Qgo) SM-SP.	39.8	2, 3, 4, 5, 6, 7, 8	During Drilling ∇
BOTTOM OF BORING COMPLETED 7/5/2006 Note: Hydrocarbon odor detected at 23.5 to 29 feet.			



LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

∇ Ground Water Level ATD

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton
Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-10

July 2006 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11

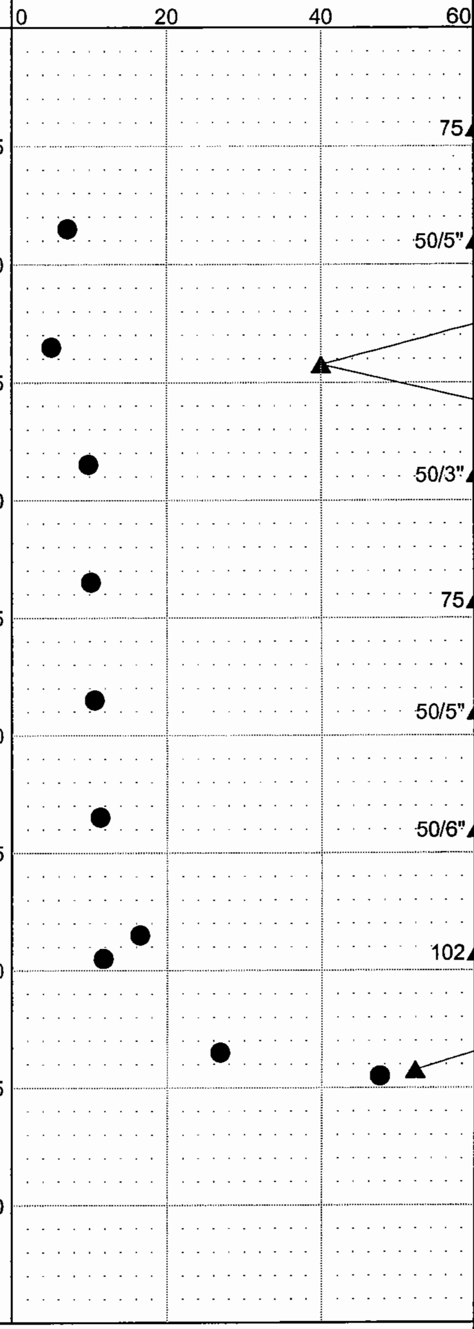
MASTER_LOG2 21-09948.GPJ SHAN_WIL.GDT 7/18/06

Log: SMP Rev: MWP Typ: LKD

SOIL DESCRIPTION	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Asphalt pavement and brick (6-inch).	0.7				
Dense to very dense, gray to brown, slightly gravelly to gravelly, slightly silty to silty SAND; moist to wet at 25 feet; (Qgo) SW-SM.			1 *, 2, 3, 4, 5, 6, 7, 8, 9	During Drilling ▽	5, 10, 15, 20, 25, 30, 35, 40
Hard, gray, silty CLAY; (Qvgl) MH/CL.	44.5				45
BOTTOM OF BORING COMPLETED 7/5/2006	45.0				50

Note: Hydrocarbon odors detected at samples 2, 4, and 7.

Penetration Resistance
(300 lb. weight - 30" drop)
▲ Blows per foot



● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

Log: SMP Rev: MWP Typ: LKD

LEGEND

* Sample Not Recovered

▽ Ground Water Level ATD

E Environmental Sample Obtained

⌶ Standard Penetration Test

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton
Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-11

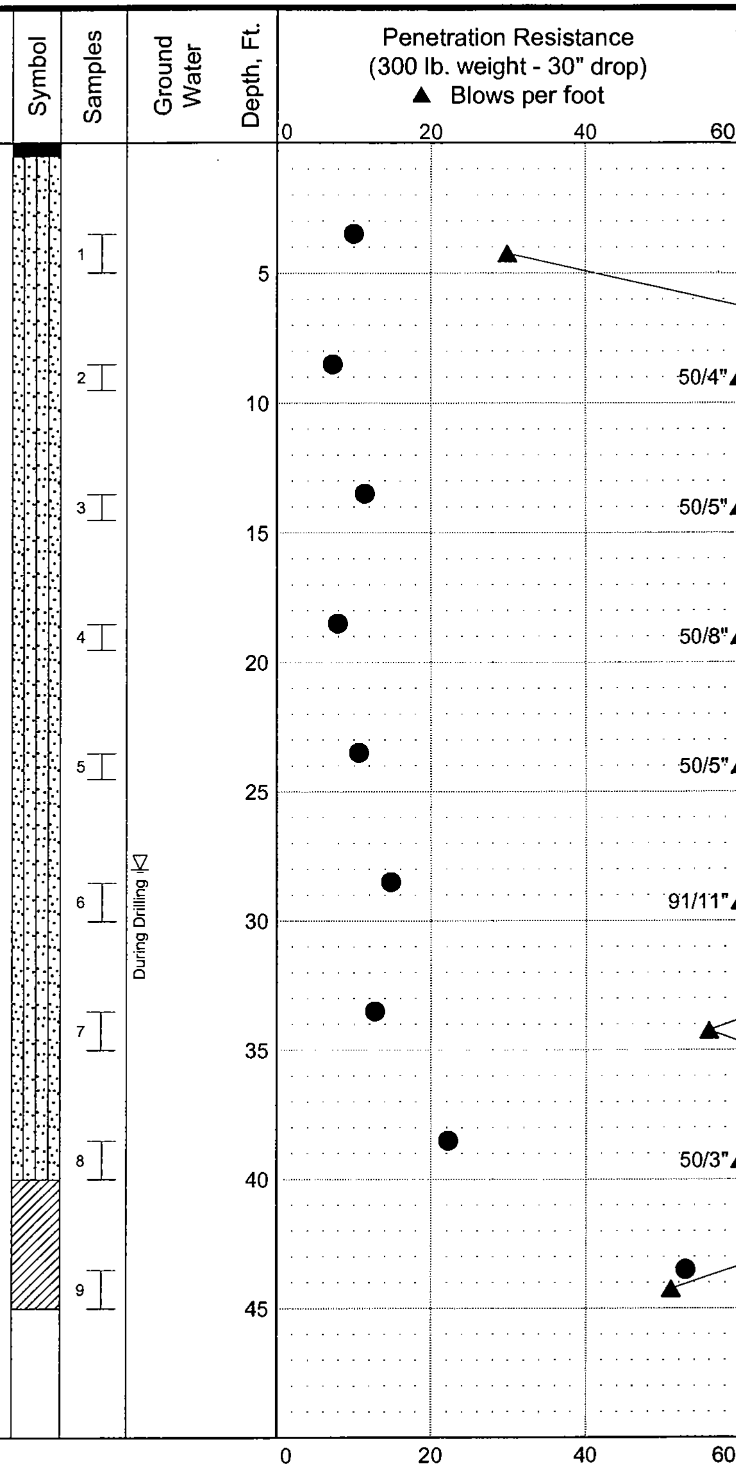
July 2006 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12

MASTER LOG2 21-09948.GPJ SHAN_WIL.GDT 7/18/06

SOIL DESCRIPTION	Depth, Ft.
Asphalt pavement and gravel.	0.5
Dense to very dense, brown to gray, slightly silty to silty, slightly gravelly to gravelly SAND; moist to wet at 24 feet; (Qgo) SM-SP.	
Hard, gray, silty CLAY; (Qpgl) CL.	40.0
BOTTOM OF BORING COMPLETED 7/8/2006 Note: Hydrocarbon odors detected at 3.5 to 25 feet.	45.0



LEGEND

* Sample Not Recovered

⊥ Standard Penetration Test

∇ Ground Water Level ATD

● % Water Content

Plastic Limit |—●—| Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-12

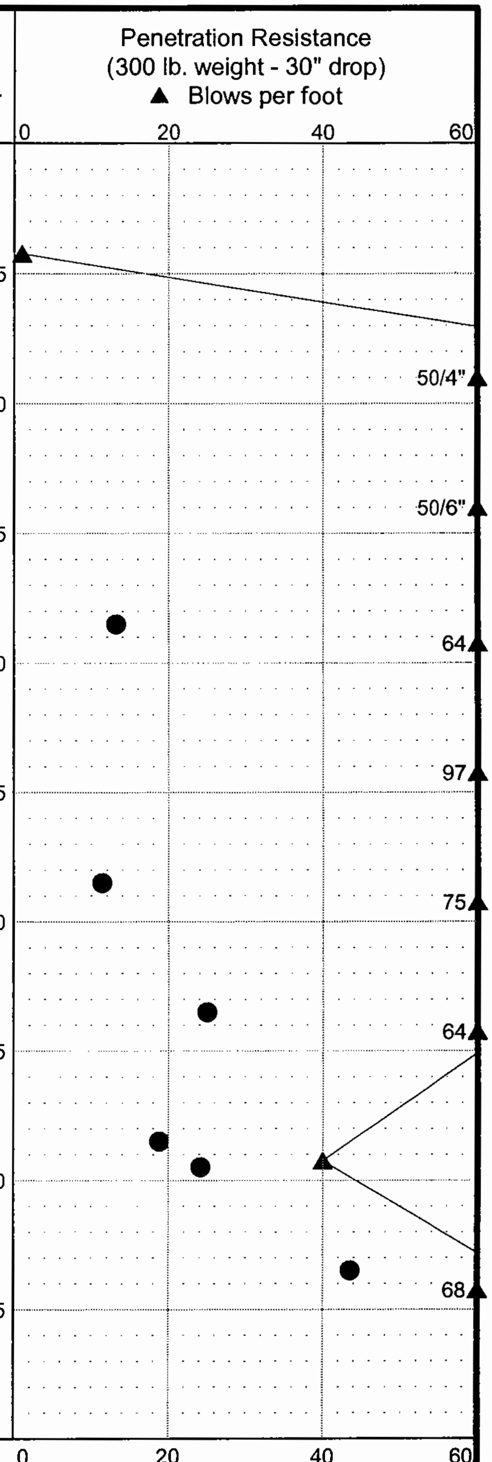
July 2006 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-13

MASTER_LOG2 21-09948.GPJ SHAN_WIL.GDT 7/18/06 Log: Rev: MWP Typ: LKD

SOIL DESCRIPTION Surface Elevation: Approx. 31.0 Ft.	Depth, Ft.	Samples	Ground Water
Asphalt pavement and gravel.	0.5		
Very loose, brown, gravelly, silty SAND; moist; (Fill) SP/SM.	5.0	1 E	
Very dense to dense, brown to gray, slightly gravelly to gravelly, slightly silty to silty SAND; moist to wet at 23 feet; (Qgo) SM-SP.	40.0	2, 3, 4, 5 E, 6, 7, 8	During Drilling ⊻
Hard, gray, silty CLAY; moist; (Qvgl) CL.	45.0	9	
BOTTOM OF BORING COMPLETED 7/8/2006 Note: Hydrocarbon odors detected at 3.5 to 20 feet.			



LEGEND

* Sample Not Recovered

⊻ Ground Water Level ATD

E Environmental Sample Obtained

⌶ Standard Penetration Test

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-13

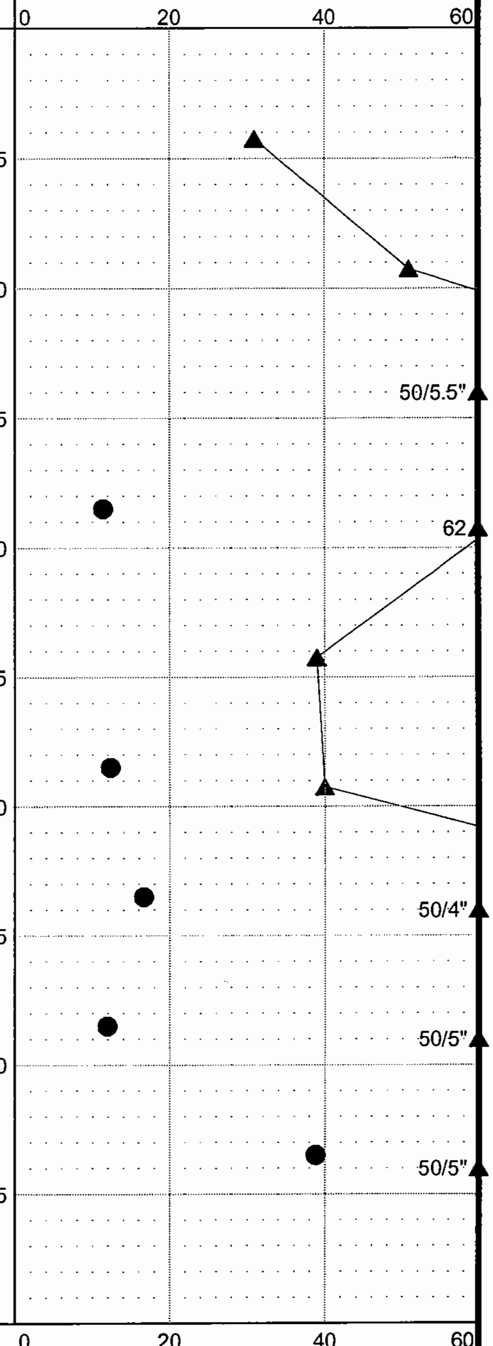
July 2006 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-14

SOIL DESCRIPTION Surface Elevation: Approx. 44.5 Ft.	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Concrete.	1.0				
Dense to very dense, brown to gray, slightly gravelly to gravelly, slightly silty to silty SAND; moist to wet at 28.5 feet; (Qgo) SM-SP.			1, 2, 3, 4, 5, 6, 7, 8, 9	During Drilling	5, 10, 15, 20, 25, 30, 35, 40, 45
BOTTOM OF BORING COMPLETED 7/6/2006 Note: Hydrocarbon odors detected at 3.5 to 25 feet.	44.5				

Penetration Resistance
(300 lb. weight - 30" drop)
▲ Blows per foot



% Water Content

Plastic Limit — Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered

Standard Penetration Test

Ground Water Level ATD

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton
Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-14

July 2006 21-1-09948-003

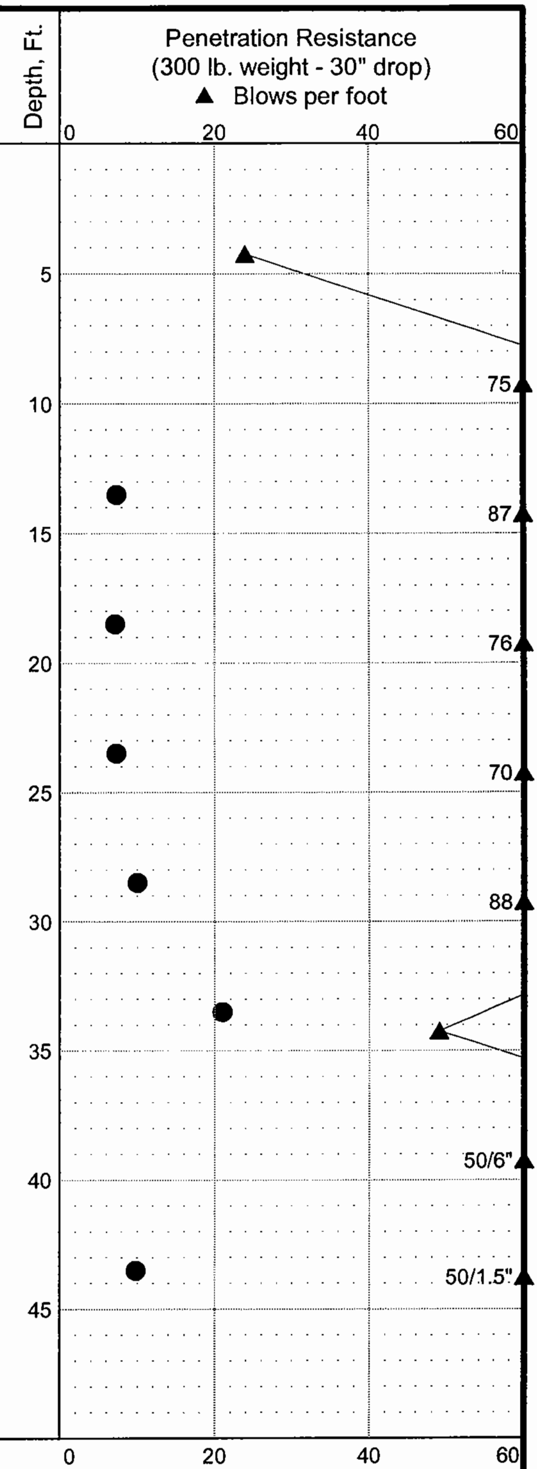
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-15

MASTER LOG2 21-09948.GPJ SHAN WIL.GDT 7/18/06

Log: NJC Rev: MWP Typ: LKD

SOIL DESCRIPTION	Depth, Ft.	Symbol	Samples	Ground Water
Surface Elevation: Approx. 18.0 Ft.				
Concrete slab.	0.4			
Medium dense to very dense, brown to gray, slightly gravelly to gravelly, slightly silty to silty SAND; moist to wet at 13.5 feet; (Qgo) SM-SP.			1, 2 E, 3, 4, 5, 6, 7, 8, 9	During Drilling ▽
BOTTOM OF BORING COMPLETED 7/6/2006	44.0			



LEGEND

- * Sample Not Recovered
- E Environmental Sample Obtained
- Ι Standard Penetration Test
- ▽ Ground Water Level ATD

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
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Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-15

July 2006 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-16

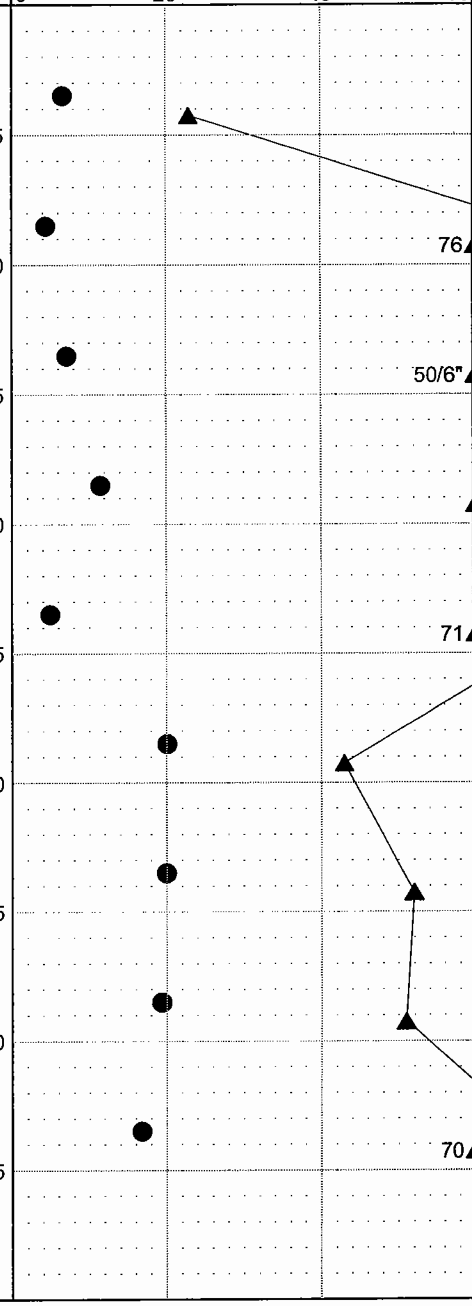
Log: NJC Rev: MWP Typ: LKD

MASTER LOG2 21-09948.GPJ SHAN WIL.GDT 7/18/06

LOG OF BORING SW-16

SOIL DESCRIPTION Surface Elevation: Approx. 33.5 Ft.	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Concrete pavement.	1.0				
Medium dense to very dense, brown to gray, slightly gravelly to gravelly, slightly silty to silty, fine to medium SAND; moist to wet at 28.5 feet; (Qgo) SM-SP.			1, 2, 3, 4, 5, 6, 7, 8, 9	During Drilling ∇	5, 10, 15, 20, 25, 30, 35, 40, 45
BOTTOM OF BORING COMPLETED 7/6/2006	45.0				

Penetration Resistance
(300 lb. weight - 30" drop)
▲ Blows per foot



0 20 40 60

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
Standard Penetration Test
∇ Ground Water Level ATD

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
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Downtown Pedestrian/Bremerton Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-16

July 2006 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-17

MASTER_LOG2 21-09948.GPJ SHAN_WIL.GDT 7/18/06 Log: NJC Rev: MWP Typ: LKD

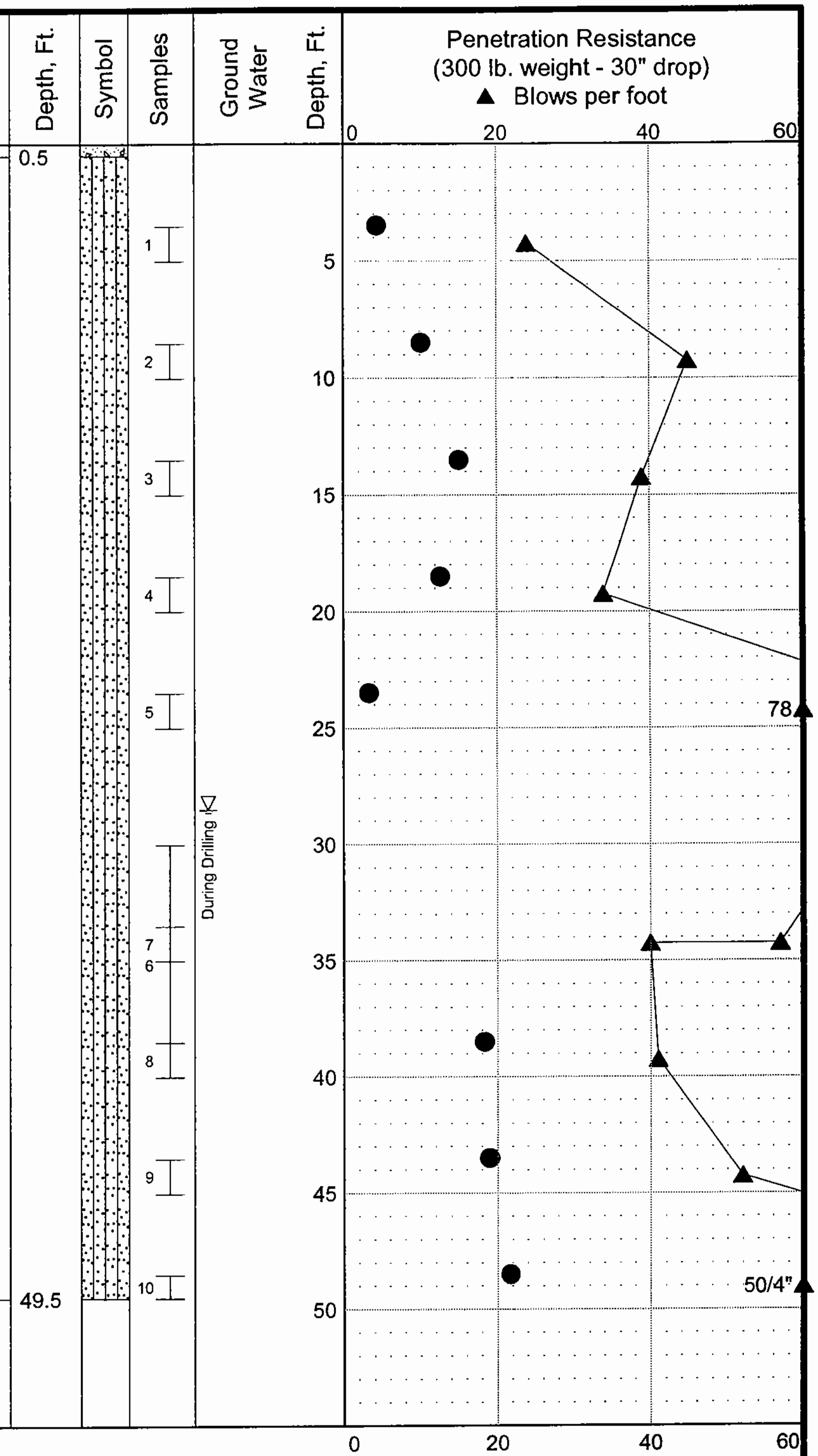
SOIL DESCRIPTION

Surface Elevation: Approx. 34.0 Ft.

Concrete floor slab. (0.5)

Medium dense to very dense, slightly gravelly to gravelly, slightly silty to silty SAND; moist to wet at 28.5 feet; (Qgo) SM-SP.

BOTTOM OF BORING
COMPLETED 7/7/2006 (49.5)



LEGEND

* Sample Not Recovered
Standard Penetration Test
Ground Water Level ATD

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
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Downtown Pedestrian/Bremerton
Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-17

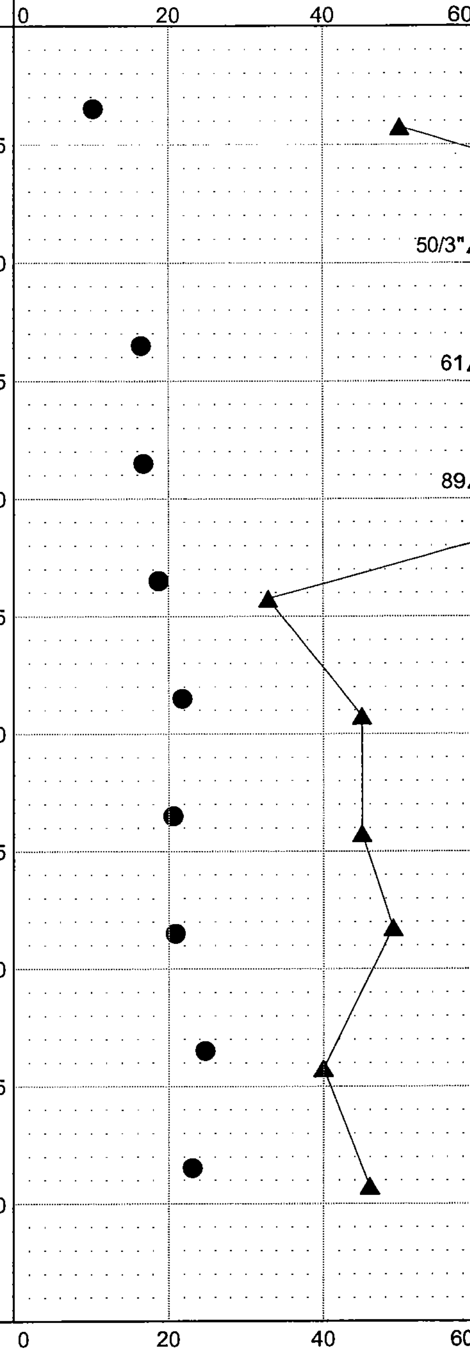
July 2006 | 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-18

SOIL DESCRIPTION Surface Elevation: Approx. 34.0 Ft.	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.
Concrete floor slab.	0.5				
Very dense to dense, brown to gray, slightly silty to silty, slightly gravelly to gravelly SAND; moist to wet at 43.5 feet; (Qgo) SM-SP.			1, 2, 3, 4, 5, 6, 7, 8, 9, 10	During Drilling ∇	5, 10, 15, 20, 25, 30, 35, 40, 45, 50
BOTTOM OF BORING COMPLETED 7/7/2006	50.0				

Penetration Resistance
(300 lb. weight - 30" drop)
▲ Blows per foot



● % Water Content

Plastic Limit |—●—| Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered

Standard Penetration Test

∇ Ground Water Level ATD

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
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Downtown Pedestrian/Bremerton
Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-18

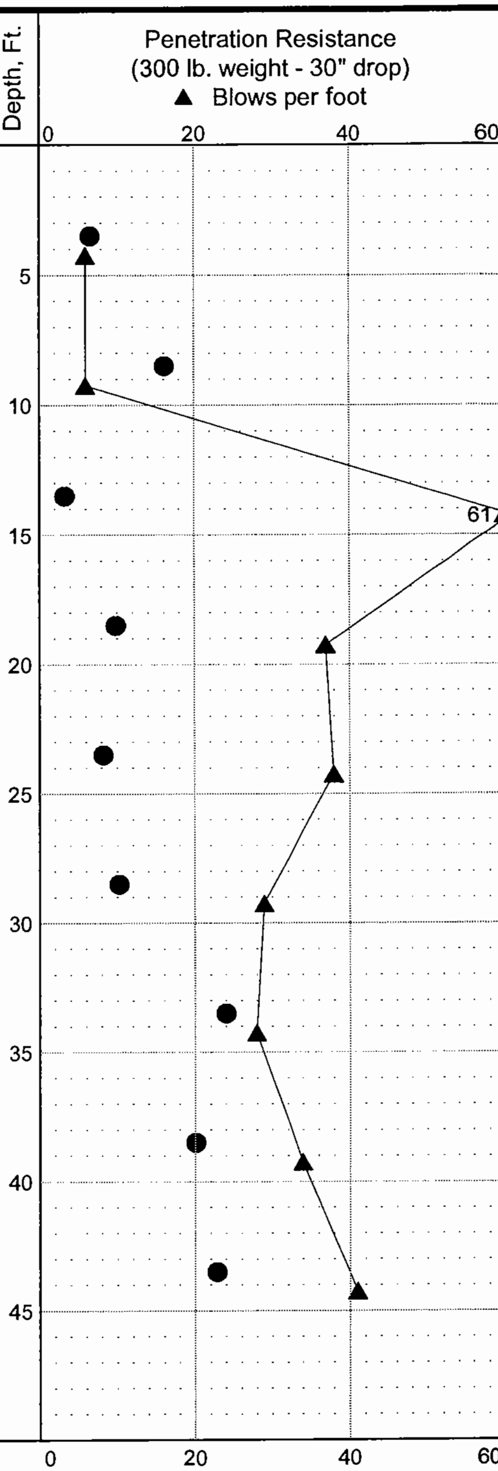
July 2006 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-19

Log: NJC Rev: MWP Typ: LKD
MASTER LOG2 21-09948.GPJ SHAN WIL.GDT 7/18/06

SOIL DESCRIPTION Surface Elevation: Approx. 39.0 Ft.	Depth, Ft.	Symbol	Samples	Ground Water
Concrete and asphalt pavement.	1.0			
Loose, brown, slightly gravelly, slightly silty, fine SAND; moist; (Fill) SP-SP/SM.			1, 2	
Very dense, slightly silty, fine SAND; moist to wet at 33.5 feet; (Qgo) SP.	10.0		3, 4, 5, 6, 7, 8, 9	During Drilling ∇
BOTTOM OF BORING COMPLETED 7/7/2006	45.0			



LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

∇ Ground Water Level ATD

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using hollow stem auger drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Downtown Pedestrian/Bremerton
Transportation Center Access Improvements
Bremerton, Washington

LOG OF BORING SW-19

July 2006 21-1-09948-003

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-20

Log: NJC Rev: MWP Typ: LKD

MASTER_LOG2 21-09948.GPJ SHAN_WIL.GDT 7/18/06

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card S15266

HOLE No. TH-1-02

Sheet 1 of 2

Job No. QE-2223   SR 304   Elevation (m)

Project SR 304 Signing Project, M.P. 2.91 Vic.

Driller Johnson   Lic# 2532

Site Address Downtown Bremerton at Burwell St. & Pacific Ave.

Inspector Hanning

Start February 10, 2002   Completion February 10, 2002   Casing Auger

Equipment CME 55 w/ autohammer

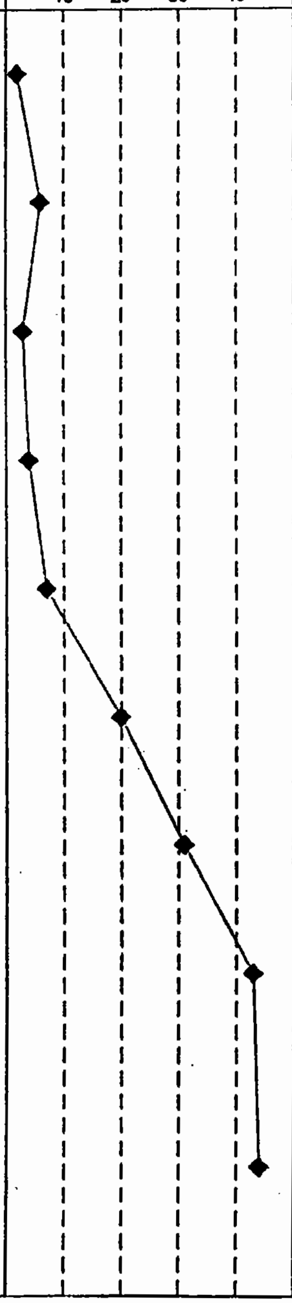
Station   Offset

Method Auger

Northing   Easting   Latitude   Longitude

County Kitsap   Subsection SW/SW   Section 13   Range 1 EWM   Township 24

Standard Penetration Blows/ft (10, 20, 30, 40)



Depth (ft)	Meters (m)	SPT Blows/6" (N)	Sample No. (Tube No.)	Description of Material
		1, 1, 1, 1 (2)	D-1	Silty SAND, very loose, brown, moist, Homogeneous, no HCl reaction, Note drilled hole in recessed plant box in sidewalk. East bound Burwell st. approximately 511' west of pacific ave, next to storm drain. Length Recovered 0.7 ft, Length Retained 0.7 ft
	1	2, 2, 4, 4 (6)	D-2	Poorly graded SAND with gravel, loose, olive brown, moist, Homogeneous, no HCl reaction Length Recovered 0.7 ft, Length Retained 0.7 ft
5		2, 1, 2, 2 (3)	D-3	Poorly graded SAND with gravel, very loose, olive brown, moist, Homogeneous, no HCl reaction Length Recovered 0.7 ft, Length Retained 0.7 ft
	2	3, 2, 2, 1 (4)	D-4	Poorly graded SAND, with trace gravel., very loose, olive gray, moist, Stratified, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft
10	3	1, 3, 4, 5 (7)	D-5	Poorly graded SAND, with some gravel, loose, olive gray, moist, Stratified, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft
		7, 9, 11, 13 (20)	D-6	Poorly graded SAND with gravel, medium dense, olive gray, moist, Stratified, no HCl reaction Length Recovered 1.3 ft, Length Retained 1.3 ft
	4	10, 14, 17, 16 (31)	D-7	Poorly graded SAND, dense, olive gray, moist, Stratified, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft
15	5	17, 20, 23, 32 (43)	D-8	Poorly graded SAND, dense, olive gray, moist, Stratified, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.5 ft
20	6	12, 19, 25, 24 (44)	D-9	Poorly graded SAND, dense, olive gray, moist, Stratified, no HCl reaction, End test boring at 20'. (No water). Length Recovered 1.5 ft, Length Retained 1.5 ft

Profile | Sample Type | Lab Tests | Groundwater | Instrument

SOIL QE2223 304 SIGN PROJECT.GPJ SOIL.GDT 4/9/03 2:48:32 P4

Washington State Department of Transportation

LOG OF TEST BORING

Start Card: S 15266
HOLE No.: TH-2-02
Sheet: 1 of 1

Job No.: QE-2223 | SR: 304 | Elevation: (m)

Project: SR 304 Signing Project, M.P. 2.91 Vic.

Driller: Jhonson | Lic#: 2532

Site Address: Downtown Bremerton at Burwell St. & Pacific Ave.

Inspector: Hanning

Start: February 10, 2002 | Completion: February 10, 2002 | Casing: Auger

Equipment: CME 55 w/ autohammer

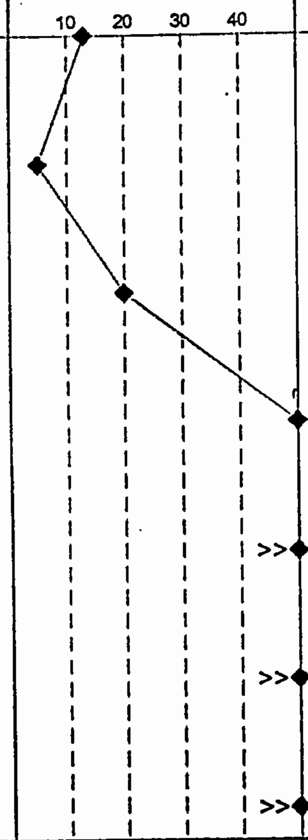
Method: Auger

Station: | Offset:

Northing: | Easting: | Latitude: | Longitude:

County: Kitsa | Subsection: SW/SW | Section: 13 | Range: 1EWM | Township: 24N

Columns: Depth (ft) | Meters (m) | Profile | Standard Penetration Blows/ft | SPT Blows/6" (N) | Sample Type | Sample No. (Tube No.) | Lab Tests | Description of Material | Groundwater | Instrument



SPT Blows/6" (N)	Sample No.	Description of Material
3, 8, 5, 4 (13)	D-1	Poorly graded SAND, with trace silt, trace organics's, & some gravel,, medium dense, brown, moist, Homogeneous, no HCl reaction. Length Recovered 1.5 ft, Length Retained 1.5 ft
3, 2, 3, 5 (5)	D-2	Silty SAND, with some gravel, loose, brown, moist, Stratified, no HCl reaction. Length Recovered 1.3 ft, Length Retained 1.3 ft
1, 5, 15, 23 (20)	D-3	Silty SAND with gravel, & trace organic's., medium dense, olive brown, moist, Stratified, no HCl reaction. Length Recovered 1.3 ft, Length Retained 1.3 ft
50/2" (50/2")	D-4	Silty GRAVEL with sand, angular, very dense, gray, moist, Homogeneous, no HCl reaction. Length Recovered 0.2 ft, Length Retained 0.2 ft
14, 38, 42, 24 (80)	D-5	Silty GRAVEL with sand, subrounded, very dense, olive brown, moist, Homogeneous, no HCl reaction. Length Recovered 1.5 ft, Length Retained 1.5 ft
26, 46, 41, 50 (87)	D-6	Silty SAND with gravel, very dense, olive gray, moist, Stratified, no HCl reaction. Length Recovered 1.8 ft, Length Retained 1.8 ft
70/6 (70/6")	D-7	Silty SAND, with trace gravel., very dense, olive gray, moist, Homogeneous, no HCl reaction, End test boring due to break down. further drilling may be necessary. Length Recovered 0.5 ft, Length Retained 0.5 ft. End of test hole boring at 12.5 ft below ground elevation.

Depth (ft) scale: 5, 10, 15, 20. Meters (m) scale: 1, 2, 3, 4, 5, 6.

This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

SOIL QE2223 304 SIGN PROJECT.GPJ SOIL.GDT 4/9/03 2:50:29 P4

FIG A-22

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-15266

HOLE No. TH-3-02

Sheet 1 of 2

Job No. QE-2223 SR 304 Elevation (m)

Project SR 304 Signing Project, M.P. 2.91 Vic.

Site Address Downtown Bremerton at Burwell St. & Pacific Ave.

Driller Vincen Johnson Lic# 2532

Inspector Brian Hilts

Start February 14, 2002 Completion February 14, 2002 Casing 20.5

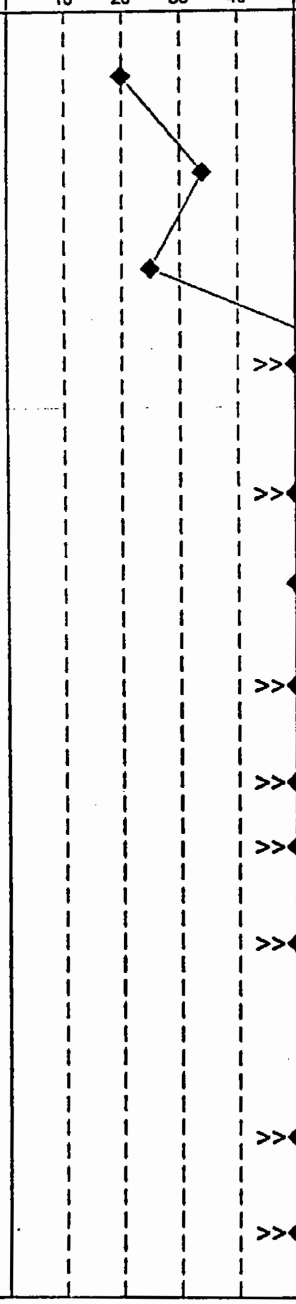
Equipment CME 55 w/ autohammer

Method Auger

Station ____ Offset ____

Northing ____ Easting ____ Latitude ____ Longitude ____

County Kitsap Subsection SW1/4 SW1/4 Section 13 Range 1 EWM Township 24



Sample No. (Tube No.)	SPT Blows/6" (N)	Description of Material
D-1	8, 9, 11 (20)	Silty GRAVEL with sand, subangular, medium dense, brown, wet, Homogeneous, no HCl reaction Length Recovered 0.7 ft, Length Retained 0.7 ft
D-2	14, 16, 18 (34)	Silty SAND with gravel, dense, light olive brown, wet, Homogeneous, no HCl reaction Length Recovered 1.1 ft, Length Retained 1.1 ft
D-3	6, 9, 16 (25)	No Recovery
D-4	19, 27, 38 (65)	Silty GRAVEL with sand, subangular, very dense, brown, wet, Homogeneous, no HCl reaction, with a trace of silt Length Recovered 0.3 ft, Length Retained 0.3 ft
D-5	12, 16, 50/5" (66)	Poorly graded SAND with gravel, very dense, grayish brown, moist, Homogeneous, no HCl reaction, with a trace of silt Length Recovered 0.8 ft, Length Retained 0.8 ft
D-6	50/3" (50/3")	Poorly graded SAND, very dense, grayish brown, moist, Homogeneous, no HCl reaction, with a trace of silt Length Recovered 0.2 ft, Length Retained 0.2 ft
D-7	7, 13, 54 (67)	Poorly graded SAND with gravel, very dense, grayish brown, dry, Homogeneous, no HCl reaction, some silt Length Recovered 0.8 ft, Length Retained 0.8 ft
D-8	85/6" (85/6")	Poorly graded SAND with gravel, very dense, grayish brown, dry, Homogeneous, no HCl reaction, with some silt Length Recovered 0.5 ft, Length Retained 0.5 ft
D-9	25, 32, 52 (84)	Silty SAND, very dense, grayish brown, moist, Stratified, no HCl reaction, the top 11" was silty sand and the bottom 7" was SP. with a trace of gravel and FeO stains. Length Recovered 1.5 ft, Length Retained 1.5 ft
D-10	60/6" (60/6")	Poorly graded SAND, very dense, grayish brown, moist, Homogeneous, no HCl reaction, with a trace of gravel and silt. Length Recovered 0.5 ft, Length Retained 0.5 ft
D-11	14, 35, 53 (88)	Silty SAND, very dense, grayish brown, moist, Stratified, no HCl reaction, stratified with sandy silt or silty fine sand with a trace of gravel. Length Recovered 1.5 ft, Length Retained 1.5 ft
D-12	61, 95/6"	Poorly graded SAND, very dense, grayish brown, moist, Homogeneous, no HCl reaction, moist to dry with a trace

Depth (ft): 5, 10, 15, 20; Meters (m): 1, 2, 3, 4, 5, 6

Columns: Depth (ft) | Meters (m) | Profile | Standard Penetration Blows/ft | SPT Blows/6" (N) | Sample Type | Sample No. (Tube No.) | Lab Tests | Description of Material | Groundwater | Instrument

SOIL QE2223 304 SIGN PROJECT.GPJ SOIL.GDT 4/9/03 2:50:30 P4

FIG. A-23

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S-15266

HOLE No. TH-3-02

Sheet 2 of 2

Job No. QE-2223 SR 304 Elevation (m)

Project SR 304 Signing Project, M.P. 2.91 Vic.

Driller Vincen Johnson Lic# 2532

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				(95/6")				of gravel. The bore hole is located 150' south of Burwell St. on the left side of Pacific Ave. 4.5' from the curb. We tripped out and the hole stayed open to 14' with no water table. Length Recovered 1.0 ft, Length Retained 1.0 ft End of test hole boring at 20 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
	7									
25										
	8									
	9									
30										
	10									
35										
	11									
	12									
40										
	13									
45										

FIG. A-23

CH2M HILL	PROJECT NUMBER: S21921.A5	BORING NUMBER: B-11	SHEET: 1 OF: 1

SOIL BORING LOG

PROJECT: BREMERTON WASTEWATER IMPROVEMENTS LOCATION: BURWELL & PARK
ELEVATION: 159.3' DRILLING CONTRACTOR: PACIFIC TESTING
DRILLING METHOD AND EQUIPMENT: 3 3/8" I.D. HOLLOW SPOON AUGER, PT 75
WATER LEVEL AND DATE: N.M. START: JAN 12, 1988 FINISH: JAN 12, 1988 LOGGER: G.W.AVOLIO

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL (FT)	SAMPLE TYPE AND NUMBER	SAMPLE REC (FT)	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
0							2" asphalt concrete.
	2.5						
	2.5–4.0	S1	1.5	3-6-7 (13)	WELL GRADED SAND with SILT and GRAVEL, brown, moist, medium dense, 60% fine to medium grained sand, 10% medium plastic silt, 30% gravel (SW-SM).		SILTY SAND with GRAVEL (SM).
5							
	7.5						
	7.5–9.0	S2	0.5	3-2-0 (2)	WELL GRADED SAND with SILT and GRAVEL, same as above except slightly plastic silt and wet (SW-SM).		Void from 8.5' to 10', basement? Wood in cuttings.
10							
	12.5						Cement (floor?) at 12.5. Possible pile - probably demolition debris.
	12.5–	S3	1.0	N.A.	Sampler filled with wood.		Moved 3', see BORING 11A.
15							
20							

SLBSYM 11/01/87

FIG. A-24

CH2M HILL

PROJECT NUMBER: S21921.A5 | BORING NUMBER: B-11A | SHEET: 1 OF: 1

SOIL BORING LOG

PROJECT: BREMERTON WASTEWATER IMPROVEMENTS LOCATION: BURWELL & PARK
ELEVATION: 159.3' DRILLING CONTRACTOR: PACIFIC TESTING
DRILLING METHOD AND EQUIPMENT: 3 3/8" I.D. HOLLOW SPOON AUGER, PT 75
WATER LEVEL AND DATE: N.M. START: JAN 12, 1988 FINISH: JAN 12, 1988 LOGGER: G.W.AVOLIO

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL (FT)	SAMPLE TYPE AND NUMBER	SAMPLE REC (FT)	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
5							
10							▽
	12.5						
		S3A	1.0	1-2-6 (8)	SILT, mottled brown, wet, soft, medium plastic with wood (ML).		Redrilled to 12.5.
	14.0						
15							
	17.5						
		S4	1.4	3-4-10 (14)	SILT, olive gray, wet, stiff, slightly plastic (ML).		
	19.0						
20							
	22.5						
		S5	1.5	8-15-19 (34)	WELL GRADED SAND, mottled tan, wet, dense, medium to coarse grained (SW).		
	24.0						
25							

SLBSYM 11/01/87

FIG. A-25

CH2M HILL

PROJECT NUMBER: S21921.A5 | BORING NUMBER: B-12 | SHEET: 1 OF: 1

SOIL BORING LOG

PROJECT: BREMERTON WASTEWATER IMPROVEMENTS LOCATION: BURWELL & PACIFIC
ELEVATION: 160.4' DRILLING CONTRACTOR: PACIFIC TESTING
DRILLING METHOD AND EQUIPMENT: 3 3/8" I.D. HOLLOW SPOON AUGER, PT 75
WATER LEVEL AND DATE: N.M. START: JAN 15, 1988 FINISH: JAN 15,1988 LOGGER: G.W.AVOLIO

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL (FT)	SAMPLE TYPE AND NUMBER	SAMPLE REC (FT)	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
0							
	2.5						
	2.5–3.5	S1	1.0	12-50 (100+)	SILTY SAND with GRAVEL, olive tan, dry to moist, very dense, 15% slightly plastic silt, 65% medium grained sand, 20% 2" minus gravel (SM).		3" gravel at 3' in cuttings.
5							
	7.5–7.9	S2	0.5	50/.4 (100+)	SILTY SAND with GRAVEL, same as above (SM).		
10							
	12.5–12.9	S3	0.5	50/.4 (100+)	SILTY SAND with GRAVEL, same as above (SM).		
15							
20							

SLBSYM 11/01/87

FIG. A-2t

CH2M HILL

PROJECT NUMBER: S21921.A5 | BORING NUMBER: B-18 | SHEET: 1 OF: 1

SOIL BORING LOG

PROJECT: BREMERTON WASTEWATER IMPROVEMENTS LOCATION: 1ST & FERRY ACCESS TUNNEL
ELEVATION: 132.1' DRILLING CONTRACTOR: PACIFIC TESTING
DRILLING METHOD AND EQUIPMENT: 4" I.D. HOLLOW STEM AUGER, PT 75
WATER LEVEL AND DATE: SEE LOG START: JAN 14, 1988 FINISH: JAN 14, 1988 LOGGER: G.W.AVOLIO

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL (FT)	SAMPLE TYPE AND NUMBER	SAMPLE REC (FT)	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
0							4" asphalt concrete.
	2.5						
		S1	1.5	1-3-4 (7)	SILTY SAND with GRAVEL, tan, wet, loose, 15% slightly plastic silt, 30% 1" minus gravel (SM).		▽
5	4.0						
	7.5						
		S2	1.5	3-2-3 (5)	SANDY SILT with GRAVEL, tan, wet, medium stiff, 30% medium grained sand, 50% medium plastic silt, 20% gravel (ML).		SILTY SAND (SM).
10	9.0						
	12.5						
		S3	1.5	6-4-15 (19)	SILTY SAND with GRAVEL, tan, wet, medium dense, 15% medium plastic silt, 60% fine to medium grained sand, 25% gravel (SM).		
15	14.0						
	17.5						
	18.0	S4	0.6	50/.5 (100+)	SILTY SAND with GRAVEL, olive tan, wet, very dense, 20% medium plastic silt, 60% medium grained sand, 20% gravel (SM).		
20							
	22.5						
	23.3	S5	0.8	25-50/.3 (100+)	SILTY SAND with GRAVEL, same as above (SM).		
25							
30							

FIG. A-27

CH2M HILL

PROJECT NUMBER: S21921.A5 | BORING NUMBER: B-19 | SHEET: 1 OF: 1

SOIL BORING LOG

PROJECT: BREMERTON WASTEWATER IMPROVEMENTS LOCATION: 1ST & WASHINGTON
ELEVATION: 141.1' DRILLING CONTRACTOR: PACIFIC TESTING
DRILLING METHOD AND EQUIPMENT: 4" I.D. HOLLOW STEM AUGER, PT 75
WATER LEVEL AND DATE: SEE LOG START: JAN 15, 1988 FINISH: JAN 15, 1988 LOGGER: G.W.AVOLIO

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL (FT)	SAMPLE TYPE AND NUMBER	SAMPLE REC (FT)	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
0							2" asphalt concrete. One course brick with sand base.
	2.5–2.7	S1	0.2	50/.2 (100+)	WELL GRADED GRAVEL with SILT and SAND, mottled brown and tan, dry, very dense, 50% gravel, 15% silt, 35% medium grained sand (GW).		On rock. 3" gravel in cuttings.
5							
							Rough drilling.
	7.5–7.8	S2	0.2	50/.3 (100+)	WELL GRADED GRAVEL with SILT and SAND, same as above except olive tan, moist, very dense (GW).		drilling hard. Heating sampler, perhaps affecting moisture.
10							Softer at 10 ft.
	12.5–12.9	S3	0.3	50/.4 (100+)	SILTY SAND with GRAVEL, olive gray, moist, very dense, 20% medium plastic silt, 60% medium grained sand, 20% 1/2" minus gravel (SM).		
15							
	17.5–18.0	S4	1.0	50/.5 (100+)	SILTY SAND with GRAVEL, same as above (SM).		
20							
	22.5						▽ ??
	22.5–22.8	S5	0.3	50/.3 (100+)	SILTY SAND with GRAVEL, same as above except saturated (SM).		
25							
30							

FIG. A-28

CH2M HILL

PROJECT NUMBER: S21921.A5 | BORING NUMBER: B-20 | SHEET: 1 OF: 1

SOIL BORING LOG

PROJECT: BREMERTON WASTEWATER IMPROVEMENTS LOCATION: 1ST, 50 FT SOUTH OF WASHINGTON
ELEVATION: 142.1' DRILLING CONTRACTOR: PACIFIC TESTING
DRILLING METHOD AND EQUIPMENT: 4" I.D. HOLLOW STEM AUGER, PT 75
WATER LEVEL AND DATE: N.M. START: JAN 15, 1988 FINISH: JAN 15, 1988 LOGGER: G.W.AVOLIO

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL (FT)	SAMPLE TYPE AND NUMBER	REC (FT)	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
0							Asphalt concrete.s
	2.5 – 4.0	S1	1.4	13-26-34 (60)	SILTY SAND, olive tan, dry, very dense, 15% slightly plastic silt, fine to medium grained sand, 10% 1-1/8" minus gravels (SM).		
5							
	7.5 – 8.5	S2	1.0	28-50 (100+)	SILTY SAND with GRAVEL, olive tan, dry, very dense, layered, 15% slightly plastic silt, fine to medium grained sand, 20% 1" minus gravel (SM).		
10							
	12.5 – 13.9	S3	1.4	15-22-50/0.4 (100+)	WELL GRADED SAND with GRAVEL, olive tan, dry, very dense, fine to medium grained sand, 20% 1-1/2" minus gravel (SM).		
15							
	17.5 – 17.7	S4	1.0	50/.2 (100+)	SILTY SAND with GRAVEL, olive tan, dry, very dense, 15% slightly plastic silt, fine to medium grained sand, 15% 1-1/2 minus gravel, beds of poorly graded medium grained sand (S).		On rock?
20							Gravel when drilling.
	22.5 – 23.0	S5	0.5	50 (100+)	SILTY SAND with GRAVEL, same as above (SM).		
25							
30							

FIG. A-29

CH2M HILL

PROJECT NUMBER: S21921.A5 | BORING NUMBER: B-21 | SHEET: 1 OF: 1

SOIL BORING LOG

PROJECT: BREMERTON WASTEWATER IMPROVEMENTS LOCATION: 1ST, BETWEEN WASHINGTON AND PACIFIC
ELEVATION: 139.7' DRILLING CONTRACTOR: PACIFIC TESTING
DRILLING METHOD AND EQUIPMENT: 4" I.D. HOLLOW STEM AUGER, PT 75
WATER LEVEL AND DATE: SEE LOG START: JAN 14, 1988 FINISH: JAN 14, 1988 LOGGER: G.W.AVOLIO

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL (FT)	SAMPLE TYPE AND NUMBER	REC (FT)	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOLIC LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
0							4-5" asphalt concrete. 1 course brick. 2" PCC.
	2.5 – 3.4	S1	1.0	10-50/.4 (100+)	SILTY SAND with GRAVEL, brown, dry, very dense, 15% slightly plastic silt, 55% medium grained sand, 30% 2" minus gravel (SM).		3" minus gravel in cuttings.
5							
	7.5 – 8.4	S2	0.8	25-50/.4 (100+)	SILTY SAND with GRAVEL, same as above, except olive tan (SM).		POORLY GRADED SAND with SILT and GRAVEL (SP-SM).
10							Smoother easier drilling at 11 ft.
	12.5 – 13.4	S3	0.8	12-50/.4 (100+)	SILTY SAND with GRAVEL, same as above (SM).		Occasional 3" or larger gravel when drilling.
15							
	17.5 – 17.9	S4	0.5	50/.4 (100+)	SILTY SAND with GRAVEL, same as above (SM).		
20							Change in drilling. ▽
	22.5 – 22.9	S5	0.4	50/.4 (100+)	SILTY SAND with GRAVEL, olive tan, wet, very dense, 15% slightly plastic silt, 65% medium grained sand, 20% 1-1/2" minus gravel (SM).		
25							
30							

FIG. A-30

=========
=========
CH2M HILL
=========

PROJECT NUMBER: S21921.A5 | BORING NUMBER: B-22 | SHEET: 1 | OF: 1

SOIL BORING LOG

PROJECT: BREMERTON WASTEWATER IMPROVEMENTS LOCATION: 1ST & PACIFIC
ELEVATION: 136.0' DRILLING CONTRACTOR: PACIFIC TESTING
DRILLING METHOD AND EQUIPMENT: 4" I.D. HOLLOW STEM AUGER, PT 75
WATER LEVEL AND DATE: SEE LOG START: JAN 14, 1988 FINISH: JAN 14, 1988 LOGGER: G.W.AVOLIO

DEPTH BELOW SURFACE (FT)	SAMPLE: INTERVAL (FT)	SAMPLE: TYPE AND NUMBER	SAMPLE: REC (FT)	STD. PEN. TEST 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY, USCS GROUP SYMBOL	SYMBOL LOG	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TEST AND INSTRUMENTATION
0							
	2.5 - 4.0	S1	1.5	3-3-3 (6)	SILTY SAND with GRAVEL, mottled brown and tan, wet, loose, 20% medium plastic silt, fine to medium grained sand, 15% 1" minus gravel (SM).		
5							
	7.5 - 9.0	S2	0.8	1-1-2 (3)	SILTY SAND with GRAVEL, same as above, except tan color (SM).		
10							∇
	12.5 - 13.2	S3	0.6	32-50/.2 (100+)	SILTY SAND, olive tan, moist, very dense, 15% slightly plastic silt, finie to medium grained sand (SM).		
15							
	17.5 - 18.3	S4	0.6	25-50/.3 (100+)	SILTY SAND with GRAVEL, olive tan, moist, very dense, 15% medium plastic silt, 20% 1-1/2" minus gravel (SM).		
20							
	22.5 - 22.8	S5	0	50/.3 (100+)	NO RECOVERY (same as above -??)		
25							
30							

FIG. A-31

DATE DRILLED: 14 Oct. 1983

SUMMARY: BORING NO. B-1

ELEVATION: 127.9

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLE NO.*	BLOWS/6"	OTHER TESTS**	FIELD MOISTURE % OF DRY WEIGHT	DRY DENSITY PCF	DESCRIPTION	SYMBOL	MOISTURE	CONSISTENCY	ELEV.
0						Surface: 6" concrete				127
	1A	12 50/ 6"		11.7		SILTY SAND; brown-gray, fine to medium, some gravel to 1" dia.	SM	moist	medium dense	
5						(from drill action: gravelly 0-4' and 4-6')				
						SAND; gray, fine	SW	wet	very dense	120
10	2A	16 50/ 6"		19.2		trace small (3/8") gravel		wet	very dense	
	3A	27 50/ 5"		15.9		gray-brown, fine, with some medium sand, trace silt at 13.5'	SP	wet	very dense	115
15										110
20	4A	19 50/ 6"		13.2		grades medium to coarse	SP	wet	very dense	
	5A	4 33 50/ 5"		16.5		gray, fine		wet	very dense	105
25						Bottom of boring at depth 24.5'				
						Groundwater encountered at depth 12'				

Note:
PSNS Datum
Mean Lower Low Water (MLLW "0" tide) = Elev. 109.1 ft
Therefore, water table is about 7' elevation, relative sea level

PRS
4/15/03

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler
C. 3-1/4" O.D. x 2-1/2" liner
D. 3-1/2" O.D. split barrel sampler
X. sample not recovered

** A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level
impervious seal
piezometer tip

PROPOSED SHEET METAL STORAGE BUILDING
Puget Sound Naval Shipyard, Bremerton
for Arnold & Arnold

Project No. 83-5178

Drawing No. 2

Converse Consultants
Geotechnical Engineering and Applied Sciences

FIG. A-32

DATE DRILLED: 14 Oct. 1983

SUMMARY: BORING NO. B-2

ELEVATION: 127.9

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLE NO.*	BLOWS/6"	OTHER TESTS**	FIELD MOISTURE % OF DRY WEIGHT	DRY DENSITY PCF	DESCRIPTION	SYMBOL	MOISTURE	CONSISTENCY	ELEVATION
0						Surface: 9" concrete				127
	1A	4 19 32	G	6.0		SAND; gray-brown, fine	SP	slightly moist	dense	
5										
	2A	11 27 40	G	18.6				wet	very dense	120
10										
	3A	16 29 40		23.2						115
15						Bottom of boring at depth 14.5' Groundwater encountered at depth 11.5'				

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler
C. 3-1/4" O.D. x 2-1/2" liner
D. 3-1/2" O.D. split barrel sampler
X. sample not recovered

** A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level
impervious seal
piezometer tip

PROPOSED SHEET METAL STORAGE BUILDING
Puget Sound Naval Shipyard, Bremerton
for Arnold & Arnold

Project No. 83-5178

Drawing No. 3

Converse Consultants
Geotechnical Engineering and Applied Sciences

FIG. A-33

DATE DRILLED: 14 Oct. 1983

SUMMARY: BORING NO. B-3

ELEVATION: 127.5

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLE NO.*	BLOWS/6"	OTHER TESTS**	FIELD MOISTURE % OF DRY WEIGHT	DRY DENSITY PCF	DESCRIPTION	SYMBOL	MOISTURE	CONSISTENCY	ELEVATION
0		13				SAND; gray-brown, f/m, with trace silt. upper 8" mixed w/angular gravel pieces to 3/4"	SW	slightly moist	dense	127
	1A	20		5.8						
	2A	23 23 50/4"	G	5.2		gravelly zone 3-5';				
5		30				3" gravel zone at 5.8'		moist	very dense	
	3A	50/3"		4.1						
						gray, fine	SP			120
		17								
	4A	40 50/6"		18.6						
10						fine to medium		∇		
		29		22.6						115
	5A	50/6"						wet	very dense	
15										
										110
	6A	19 50/6"		23.0						
20										
		4								105
	7A	27 50/4"		19.8				wet	very dense	
25										

Bottom of boring at depth 24.3'
Groundwater encountered at depth 12

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler
C. 3-1/4" O.D. x 2-1/2" liner
D. 3-1/2" O.D. split barrel sampler
X. sample not recovered

**A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level
impervious seal
piezometer tip

PROPOSED SHEET METAL STORAGE BUILDING
Puget Sound Naval Shipyard, Bremerton
for Arnold & Arnold

Project No. 83-5178

Drawing No. 4

Converse Consultants
Geotechnical Engineering and Applied Sciences

FIG. A-34

APPENDIX B

GEOTECHNICAL LABORATORY TESTING PROCEDURES AND RESULTS

APPENDIX B

GEOTECHNICAL LABORATORY TESTING PROCEDURES AND RESULTS

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Figure No.

APPENDIX B

GEOTECHNICAL LABORATORY TESTING PROCEDURES AND RESULTS

B.1 VISUAL CLASSIFICATION

All soil samples recovered from the borings were visually classified using a system based on the American Society for Testing and Materials (ASTM) Designation: D 2487, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM Designation: D 2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). These ASTM standards use the Unified Soil Classification System (USCS), described in Figure A-1. The visual classification made using this system allows for convenient and consistent comparison of soils from widespread geographic areas.

The individual sample classifications have been incorporated into the Shannon & Wilson boring logs presented in Figures A-2 through A-7.

B.2 WATER CONTENT DETERMINATION

The natural water content of all soil samples recovered from the field explorations was determined in general accordance with ASTM Designation: D 2216, Standard Method of Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures. Comparison of natural water content of a soil with its index properties can be useful in characterizing soil unit weight, consistency, compressibility, and strength.

The water content is plotted in the borings logs.

B.3 SIEVE ANALYSIS

Grain size analysis was performed on 14 selected samples in general accordance with ASTM Designation: D 422, Standard Method for Particle-Size Analysis of Soils. Three general procedures are available to determine the grain size distribution of a soil sample: sieve analysis, hydrometer analysis, and combined analysis. For this project, only sieve analyses were performed.

Grain size distribution is used to assist in classifying soils and to provide correlation with soil properties, including permeability, liquefaction potential, capillary action, and sensitivity to moisture. Results of the grain size analyses are plotted on grain size distribution curves presented in Figures B-1 through B-3. Along with the grain size distribution is a tabulated summary containing the sample classification, percentage of fines passing the No. 200 sieve, and natural water content.

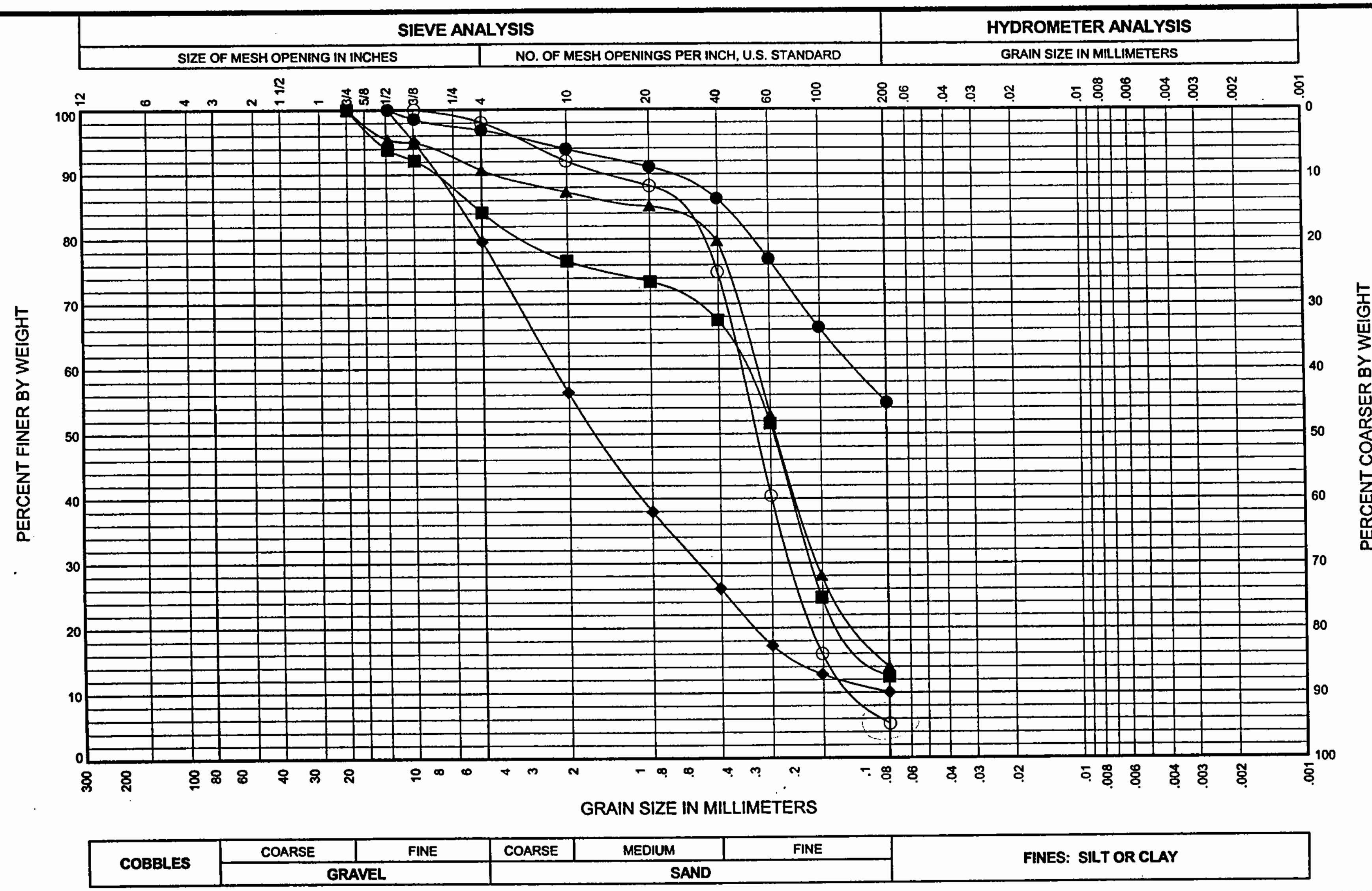
B.4 ATTERBERG LIMITS DETERMINATION

The Atterberg Limits were determined on one sample of fine-grained soil encountered near the bottom of boring SW-1. This test was performed in general accordance with ASTM Designation: D 4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. The Atterberg Limits include Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI=LL-PL). These limits are generally used to assist in classification of soils, to indicate soil consistency (when compared with natural water content), and to provide correlation with soil properties, including compressibility and strength.

The results of the Atterberg Limits determination on sample S-15 of boring SW-1 are shown on the plasticity chart presented as Figure B-4.

B.5 REFERENCE

American Society for Testing and Materials (ASTM) International, 2002, Annual book of standards: West Conshohocken, Pa., American Society for Testing and Materials, Construction, v. 4.08, Soil and Rock (I): D 420-D 4914.



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-1, S-9	25.0	ML	Brown, sandy SILT, trace of gravel	54.7	12.4			
■ SW-1, S-10	30.0	SM	Brown-gray, silty, gravelly SAND	12.4	14.5			
▲ SW-1, S-11	35.0	SM	Brown-gray, slightly gravelly, silty SAND	13.9	16.1			
◆ SW-2, S-8	20.0	SW-SM	Brown-gray, slightly silty, gravelly SAND	10.0	11.4			
○ SW-2, S-9	25.0	SP-SM	Brown-gray, slightly silty SAND, trace of gravel	5.3	18.6			

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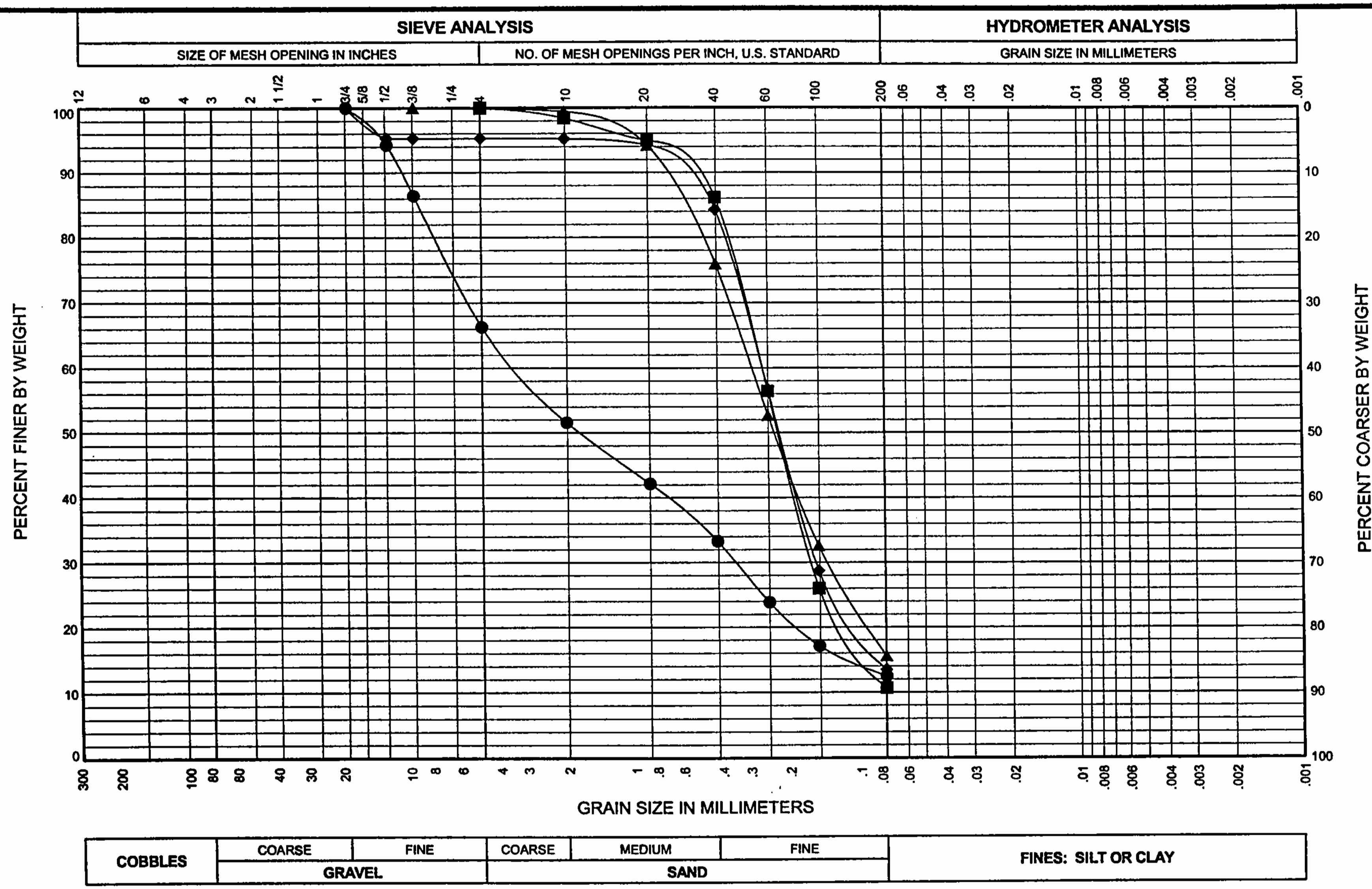
FIG. B-1

FIG. B-1



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-3, S-10	27.5	SM	Brown-gray, silty, gravelly SAND	12.5	9.0			
■ SW-3, S-13	42.5	SP-SM	Brown, slightly silty, fine to medium SAND	10.7	21.5			
▲ SW-4, S-11	32.5	SM	Brown, silty, fine to medium SAND	15.5	17.2			
◆ SW-4, S-13	42.5	SM	Brown, silty, fine to medium SAND, trace of gravel	13.4	17.5			

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Transportation Center Access Improvements
Bremerton, Washington

GRAIN SIZE DISTRIBUTION

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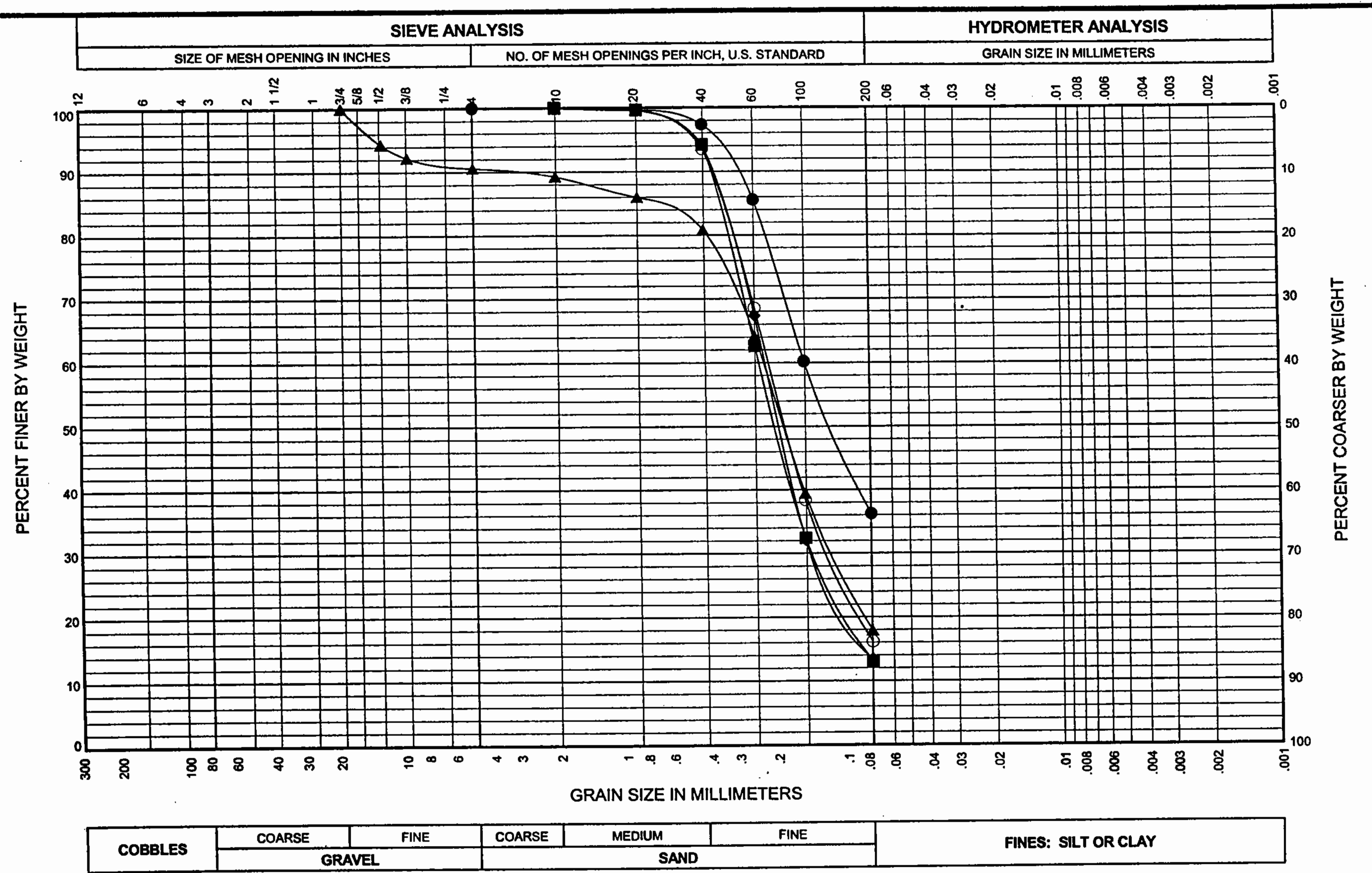
FIG. B-2

FIG. B-2



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-5, S-11	35.0	SM	Brown, silty, fine SAND	36.2	21.5			
■ SW-5, S-12	40.0	SM	Brown, silty, fine to medium SAND	13.1	23.8			
▲ SW-6, S-9	25.0	SM	Brown, slightly gravelly, silty, fine to medium SAND	17.9	8.4			
◆ SW-6, S-10	30.0	SM	Brown, silty, fine to medium SAND	13.3	20.7			
○ SW-6, S-12	40.0	SM	Brown, silty, fine to medium SAND	16.1	21.5			

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Transportation Center Access Improvements
Bremerton, Washington

GRAIN SIZE DISTRIBUTION

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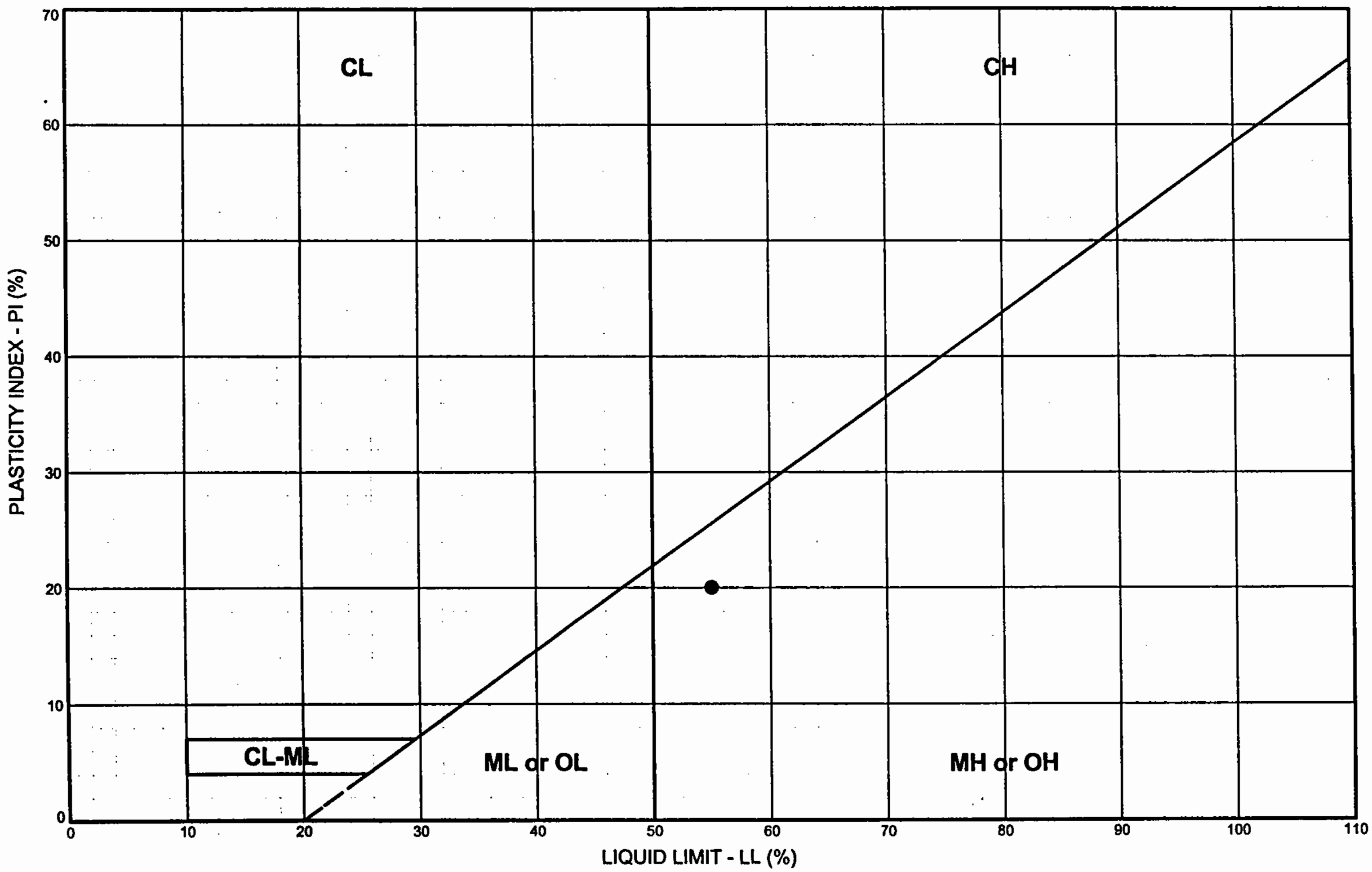
FIG. B-3

FIG. B-3



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-1, S-15	55.0	MH	Gray, slightly sandy, clayey SILT	55	35	20	38.2	

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Bremerton, Washington

PLASTICITY CHART

November 2005 — 21-1-09948-003

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FIG. B-4

FIG. B-4

APPENDIX C

ANALYTICAL TESTING RESULTS

APPENDIX C

ANALYTICAL TESTING RESULTS

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APPENDIX C
ANALYTICAL TESTING RESULTS

Four soil samples and two groundwater samples were collected for laboratory analysis from borings SW-3 and SW-4. Soil samples were tested by OnSite Environmental, Inc. (OSE), in Redmond, Washington, using the following laboratory procedures: Northwest Total Petroleum Hydrocarbons Gasoline-Range Organics (NWTPH-Gx); and volatile organic compounds (VOCs) by U.S. Environmental Protection Agency (EPA) Method 8260B. Water samples were tested for Gasoline-Range Organics with benzene, toluene, ethylbenzene, and xylenes (NWTPH-Gx/ BTEX). Boring logs are located in Appendix A.

The four soil samples were tested for gasoline-range organics. Gasoline was detected in one soil sample from boring SW-3, SW3-S1 (50 milligrams per kilogram [mg/kg]), and two samples from boring SW-4, SW4-S-1@2.5-4 (7.1 mg/kg) and SW4-S-2@5-7.5 (6 mg/kg). The gasoline contamination encountered was below the Model Toxics Control Act (MTCA) Method A cleanup level of 100 mg/kg. The fourth soil sample, collected from boring SW-3, SW3-S2, exhibited no gasoline contamination above the laboratory practical quantitation limit. Of the four soil samples, only one, SW3-S1, exhibited VOCs. The concentrations of the four detected analytes were low, ranging from around 1 to 8 micrograms per kilogram (µg/kg). According to OSE personnel, the detected analytes are consistent with gasoline-range solvents. Groundwater samples did not exhibit gasoline or BTEX above the laboratory practical quantitation limit. Analytical results are presented in Tables 1 and 2, and analytical data reports are attached.

Based on this information, contaminant concentrations in the soil and groundwater at the sampling locations appear low. However, the detected analyte concentrations in the soil samples may not accurately represent the actual site soil contaminant concentrations, because samples were initially collected for geotechnical purposes and not handled by EPA protocol. Groundwater samples were handled by EPA protocol and did not exhibit analytes.

Boring SW-3 was placed adjacent to the following validated sites: the U.S. Bank property, the former Jay Jacobs property, and the Moffit Building. Boring SW-4 was placed near the following validated sites: the former Woolworth's property, the former Hotel property, the former Photo Finisher property, the former Armitage Motor Co. property, and the Navy Yard Shopping Center property. The soil and/or groundwater of these properties is potentially contaminated, as discussed in Chapter 4 of the Hazardous Waste Discipline Report. During soil excavation in the site corridor along these properties, groundwater collected during dewatering may require additional groundwater testing and, if contaminated, special handling and disposal.

TABLE C-1
SOIL ANALYTICAL RESULTS

Sample ID	Boring	Matrix	Sample Depth (feet)	Gasoline	VOCs
SW3-S1	SW-3	Soil	2.5-4	50	1,3,5-Trimethylbenzene = 0.0034 1,2,4-Trimethylbenzene = 0.0078 sec-Butylbenzene = 0.0016 p-Isopropyltoluene = 0.0038
SW3-S2	SW-3	Soil	5-6.5	ND	ND
S-1@2.5-4	SW-4	Soil	2.5-4	7.1	ND
S-2@5-7.5	SW-4	Soil	5-7.5	6.0	ND
MTCA Method A Unrestricted Land Use (soil)				100	--

Results in milligrams per kilogram (mg/kg).
MTCA = Washington Model Toxics Control Act
ND = not detected
VOCs = volatile organic compounds

TABLE C-2
GROUNDWATER ANALYTICAL RESULTS

Sample ID	Matrix	Gasoline	Benzene	Toluene	Ethylbenzene	Xylenes
SW3-033104	Water	ND	ND	ND	ND	ND
SW4-033104	Water	ND	ND	ND	ND	ND
MTCA Method A (groundwater)		1,000	5	1,000	700	1,000

Water sample results measured in micrograms per liter (ug/L).

MTCA = Washington Model Toxics Control Act

ND = not detected

TABLE C-3
GROUNDWATER ANALYTICAL RESULTS FOR SW-2 AND SW-3

Well Number	Sample Number	Date Collected	NWTPH-HCID		
			Gasoline	Diesel	Lube Oil
SW-2	SW2-021406	2/14/2006	ND<0.12	ND<0.29	ND<0.47
SW-3	SW3-021506	2/15/2006	ND<0.11	ND<0.27	ND<0.43
MTCA Method A (groundwater)			0.8 or 1.0*	0.5	0.5

Water sample results measured in milligrams per liter (mg/L).

* = Gasoline Method A cleanup level 0.8 mg/L if benzene is present, 1.0 mg/L otherwise

MTCA = Washington Model Toxics Control Act

ND = not detected

NWTPH-HCID = Northwest Total Petroleum Hydrocarbons - Hydrocarbon Identification

OnSite
Environmental Inc.
Analytical Testing and Mobile Laboratory Services

March 15, 2004

Scott Gaulke
Shannon & Wilson, Inc.
400 N 34th Street, Suite 100
Seattle, WA 98103

Re: Analytical Data for Project 21-1-09948-001
Laboratory Reference No. 0403-046

Dear Scott:

Enclosed are the analytical results and associated quality control data for samples submitted on March 5, 2004.

The standard policy of OnSite Environmental Inc. is to store your samples for 30 days from the date of receipt. If you require longer storage, please contact the laboratory.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning the data, or need additional information, please feel free to call me.

Sincerely,

David Baumeister
Project Manager

Enclosures

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

Case Narrative

Samples were collected on March 2, 2004 and received by the laboratory on March 5, 2004. They were maintained at the laboratory at a temperature of 2°C to 6°C.

General QA/QC issues associated with the analytical data enclosed in this laboratory report will be indicated with a reference to a comment or explanation on the Data Qualifier page. More complex and involved QA/QC issues will be discussed in detail below.

NWTPH Gx Analysis

The chromatogram for sample SW3-S1 is similar to mineral spirits.

Any other QA/QC issues associated with this extraction and analysis will be indicated with a footnote reference and discussed in detail on the Data Qualifier page.

Volatiles EPA 8260B Analysis

The sample container for sample SW3-S1 was the incorrect type of container and contained headspace.

Any other QA/QC issues associated with this extraction and analysis will be indicated with a footnote reference and discussed in detail on the Data Qualifier page.

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

NWTPH-Gx

Date Extracted: 3-10-04
Date Analyzed: 3-10-04

Matrix: Soil
Units: mg/kg (ppm)

Client ID:	**SW3-S2**			**SW3-S1**		
Lab ID:	03-046-01			03-046-02		
	Result	Flags	PQL	**Result**	Flags	PQL
TPH-Gas	**ND**		5.6	**50**	**Z**	5.7
Surrogate Recovery:						
Fluorobenzene	89%			88%		

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

NWTPH-Gx
METHOD BLANK QUALITY CONTROL

Date Extracted: 3-10-04
Date Analyzed: 3-10-04

Matrix: Soil
Units: mg/kg (ppm)

Lab ID: MB0310S2

	Result	Flags	PQL
TPH-Gas	ND		5.0
Surrogate Recovery:			
Fluorobenzene	94%		

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

NWTPH-Gx
METHOD BLANK QUALITY CONTROL

Date Extracted: 3-12-04
Date Analyzed: 3-12-04

Matrix: Soil
Units: mg/kg (ppm)

Lab ID: MB0312S1

	Result	Flags	PQL
TPH-Gas	**ND**		5.0
Surrogate Recovery:			
Fluorobenzene	96%		

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

NWTPH-Gx
DUPLICATE QUALITY CONTROL

Date Extracted: 3-12-04
Date Analyzed: 3-12-04

Matrix: Soil
Units: mg/kg (ppm)

Lab ID:	03-065-02 Original	03-065-02 Duplicate	RPD	Flags
TPH-Gas	**5.65**	**6.15**	9	
Surrogate Recovery:				
Fluorobenzene	90%	93%		

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

VOLATILES by EPA 8260B
Page 1 of 2

Date Extracted: 3-9-04
Date Analyzed: 3-9-04

Matrix: Soil
Units: mg/kg (ppm)

Lab ID: 03-046-01
Client ID: SW3-S2

Compound	Results	Flags	PQL
Dichlorodifluoromethane	ND		0.0011
Chloromethane	ND		0.0011
Vinyl Chloride	ND		0.0011
Bromomethane	ND		0.0011
Chloroethane	ND		0.0011
Trichlorofluoromethane	ND		0.0011
1,1-Dichloroethene	ND		0.0011
Acetone	ND		0.0056
Iodomethane	ND		0.0056
Carbon Disulfide	ND		0.0011
Methylene Chloride	ND		0.0056
(trans) 1,2-Dichloroethene	ND		0.0011
Methyl t-Butyl Ether	ND		0.0011
1,1-Dichloroethane	ND		0.0011
Vinyl Acetate	ND		0.0056
2,2-Dichloropropane	ND		0.0011
(cis) 1,2-Dichloroethene	ND		0.0011
2-Butanone	ND		0.0056
Bromochloromethane	ND		0.0011
Chloroform	ND		0.0011
1,1,1-Trichloroethane	ND		0.0011
Carbon Tetrachloride	ND		0.0011
1,1-Dichloropropene	ND		0.0011
Benzene	ND		0.0011
1,2-Dichloroethane	ND		0.0011
Trichloroethene	ND		0.0011
1,2-Dichloropropane	ND		0.0011
Dibromomethane	ND		0.0011
Bromodichloromethane	ND		0.0011
2-Chloroethyl Vinyl Ether	ND		0.0056
(cis) 1,3-Dichloropropene	ND		0.0011
Methyl Isobutyl Ketone	ND		0.0056
Toluene	ND		0.0011
(trans) 1,3-Dichloropropene	ND		0.0011

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

VOLATILES by EPA 8260B
Page 2 of 2

Lab ID: 03-046-01
Client ID: SW3-S2

Compound	Results	Flags	PQL
1,1,2-Trichloroethane	ND		0.0011
Tetrachloroethene	ND		0.0011
1,3-Dichloropropane	ND		0.0011
2-Hexanone	ND		0.0056
Dibromochloromethane	ND		0.0011
1,2-Dibromoethane	ND		0.0011
Chlorobenzene	ND		0.0011
1,1,1,2-Tetrachloroethane	ND		0.0011
Ethylbenzene	ND		0.0011
m,p-Xylene	ND		0.0022
o-Xylene	ND		0.0011
Styrene	ND		0.0011
Bromoform	ND		0.0011
Isopropylbenzene	ND		0.0011
Bromobenzene	ND		0.0011
1,1,2,2-Tetrachloroethane	ND		0.0011
1,2,3-Trichloropropane	ND		0.0011
n-Propylbenzene	ND		0.0011
2-Chlorotoluene	ND		0.0011
4-Chlorotoluene	ND		0.0011
1,3,5-Trimethylbenzene	ND		0.0011
tert-Butylbenzene	ND		0.0011
1,2,4-Trimethylbenzene	ND		0.0011
sec-Butylbenzene	ND		0.0011
1,3-Dichlorobenzene	ND		0.0011
p-Isopropyltoluene	ND		0.0011
1,4-Dichlorobenzene	ND		0.0011
1,2-Dichlorobenzene	ND		0.0011
n-Butylbenzene	ND		0.0011
1,2-Dibromo-3-chloropropane	ND		0.0056
1,2,4-Trichlorobenzene	ND		0.0011
Hexachlorobutadiene	ND		0.0056
Naphthalene	ND		0.0011
1,2,3-Trichlorobenzene	ND		0.0011

Surrogate	Percent Recovery	Control Limits
Dibromofluoromethane	90	71-126
Toluene, d8	89	73-130
4-Bromofluorobenzene	103	70-130

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

VOLATILES by EPA 8260B

Date Extracted: 3-9-04
Date Analyzed: 3-9-04

Matrix: Soil
Units: mg/kg (ppm)

Lab ID: 03-046-02
Client ID: SW3-S1

Compound	Results	Flags	PQL
Dichlorodifluoromethane	ND		0.0011
Chloromethane	ND		0.0011
Vinyl Chloride	ND		0.0011
Bromomethane	ND		0.0011
Chloroethane	ND		0.0011
Trichlorofluoromethane	ND		0.0011
1,1-Dichloroethene	ND		0.0011
Acetone	ND		0.0057
Iodomethane	ND		0.0057
Carbon Disulfide	ND		0.0011
Methylene Chloride	ND		0.0057
(trans) 1,2-Dichloroethene	ND		0.0011
Methyl t-Butyl Ether	ND		0.0011
1,1-Dichloroethane	ND		0.0011
Vinyl Acetate	ND		0.0057
2,2-Dichloropropane	ND		0.0011
(cis) 1,2-Dichloroethene	ND		0.0011
2-Butanone	ND		0.0057
Bromochloromethane	ND		0.0011
Chloroform	ND		0.0011
1,1,1-Trichloroethane	ND		0.0011
Carbon Tetrachloride	ND		0.0011
1,1-Dichloropropene	ND		0.0011
Benzene	ND		0.0011
1,2-Dichloroethane	ND		0.0011
Trichloroethene	ND		0.0011
1,2-Dichloropropane	ND		0.0011
Dibromomethane	ND		0.0011
Bromodichloromethane	ND		0.0011
2-Chloroethyl Vinyl Ether	ND		0.0057
(cis) 1,3-Dichloropropene	ND		0.0011
Methyl Isobutyl Ketone	ND		0.0057
Toluene	ND		0.0011
(trans) 1,3-Dichloropropene	ND		0.0011

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

VOLATILES by EPA 8260B
Page 2 of 2

Lab ID: 03-046-02
Client ID: SW3-S1

Compound	Results	Flags	PQL
1,1,2-Trichloroethane	ND		0.0011
Tetrachloroethene	ND		0.0011
1,3-Dichloropropane	ND		0.0011
2-Hexanone	ND		0.0057
Dibromochloromethane	ND		0.0011
1,2-Dibromoethane	ND		0.0011
Chlorobenzene	ND		0.0011
1,1,1,2-Tetrachloroethane	ND		0.0011
Ethylbenzene	ND		0.0011
m,p-Xylene	ND		0.0023
o-Xylene	ND		0.0011
Styrene	ND		0.0011
Bromoform	ND		0.0011
Isopropylbenzene	ND		0.0011
Bromobenzene	ND		0.0011
1,1,2,2-Tetrachloroethane	ND		0.0011
1,2,3-Trichloropropane	ND		0.0011
n-Propylbenzene	ND		0.0011
2-Chlorotoluene	ND		0.0011
4-Chlorotoluene	ND		0.0011
1,3,5-Trimethylbenzene	0.0034		0.0011
tert-Butylbenzene	ND		0.0011
1,2,4-Trimethylbenzene	0.0078		0.0011
sec-Butylbenzene	0.0016		0.0011
1,3-Dichlorobenzene	ND		0.0011
p-Isopropyltoluene	0.0038		0.0011
1,4-Dichlorobenzene	ND		0.0011
1,2-Dichlorobenzene	ND		0.0011
n-Butylbenzene	ND		0.0011
1,2-Dibromo-3-chloropropane	ND		0.0057
1,2,4-Trichlorobenzene	ND		0.0011
Hexachlorobutadiene	ND		0.0057
Naphthalene	ND		0.0011
1,2,3-Trichlorobenzene	ND		0.0011

Surrogate	Percent Recovery	Control Limits
Dibromofluoromethane	76	71-126
Toluene, d8	87	73-130
4-Bromofluorobenzene	81	70-130

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

VOLATILES by EPA 8260B
METHOD BLANK QUALITY CONTROL
Page 1 of 2

Date Extracted: 3-9-04
Date Analyzed: 3-9-04

Matrix: Soil
Units: mg/kg (ppm)

Lab ID: MB0309S1

Compound	Results	Flags	PQL
Dichlorodifluoromethane	ND		0.0010
Chloromethane	ND		0.0010
Vinyl Chloride	ND		0.0010
Bromomethane	ND		0.0010
Chloroethane	ND		0.0010
Trichlorofluoromethane	ND		0.0010
1,1-Dichloroethene	ND		0.0010
Acetone	ND		0.0050
Iodomethane	ND		0.0050
Carbon Disulfide	ND		0.0010
Methylene Chloride	ND		0.0050
(trans) 1,2-Dichloroethene	ND		0.0010
Methyl t-Butyl Ether	ND		0.0010
1,1-Dichloroethane	ND		0.0010
Vinyl Acetate	ND		0.0050
2,2-Dichloropropane	ND		0.0010
(cis) 1,2-Dichloroethene	ND		0.0010
2-Butanone	ND		0.0050
Bromochloromethane	ND		0.0010
Chloroform	ND		0.0010
1,1,1-Trichloroethane	ND		0.0010
Carbon Tetrachloride	ND		0.0010
1,1-Dichloropropene	ND		0.0010
Benzene	ND		0.0010
1,2-Dichloroethane	ND		0.0010
Trichloroethene	ND		0.0010
1,2-Dichloropropane	ND		0.0010
Dibromomethane	ND		0.0010
Bromodichloromethane	ND		0.0010
2-Chloroethyl Vinyl Ether	ND		0.0050
(cis) 1,3-Dichloropropene	ND		0.0010
Methyl Isobutyl Ketone	ND		0.0050
Toluene	ND		0.0010
(trans) 1,3-Dichloropropene	ND		0.0010

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

VOLATILES by EPA 8260B
METHOD BLANK QUALITY CONTROL
Page 2 of 2

Lab ID: MB0309S1

Compound	Results	Flags	PQL
1,1,2-Trichloroethane	ND		0.0010
Tetrachloroethene	ND		0.0010
1,3-Dichloropropane	ND		0.0010
2-Hexanone	ND		0.0050
Dibromochloromethane	ND		0.0010
1,2-Dibromoethane	ND		0.0010
Chlorobenzene	ND		0.0010
1,1,1,2-Tetrachloroethane	ND		0.0010
Ethylbenzene	ND		0.0010
m,p-Xylene	ND		0.0020
o-Xylene	ND		0.0010
Styrene	ND		0.0010
Bromoform	ND		0.0010
Isopropylbenzene	ND		0.0010
Bromobenzene	ND		0.0010
1,1,2,2-Tetrachloroethane	ND		0.0010
1,2,3-Trichloropropane	ND		0.0010
n-Propylbenzene	ND		0.0010
2-Chlorotoluene	ND		0.0010
4-Chlorotoluene	ND		0.0010
1,3,5-Trimethylbenzene	ND		0.0010
tert-Butylbenzene	ND		0.0010
1,2,4-Trimethylbenzene	ND		0.0010
sec-Butylbenzene	ND		0.0010
1,3-Dichlorobenzene	ND		0.0010
p-Isopropyltoluene	ND		0.0010
1,4-Dichlorobenzene	ND		0.0010
1,2-Dichlorobenzene	ND		0.0010
n-Butylbenzene	ND		0.0010
1,2-Dibromo-3-chloropropane	ND		0.0050
1,2,4-Trichlorobenzene	ND		0.0010
Hexachlorobutadiene	ND		0.0050
Naphthalene	ND		0.0010
1,2,3-Trichlorobenzene	ND		0.0010

Surrogate	Percent Recovery	Control Limits
Dibromofluoromethane	88	71-126
Toluene, d8	89	73-130
4-Bromofluorobenzene	84	70-130

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

VOLATILES by EPA 8260B
MS/MSD QUALITY CONTROL

Date Extracted: 3-9-04
Date Analyzed: 3-9-04

Matrix: Soil
Units: mg/kg (ppm)

Lab ID: 03-053-06

Compound	Sample Amount	Spike Amount	MS	Percent Recovery	MSD	Percent Recovery	Recovery Limits	Flags
1,1-Dichloroethene	ND	0.0500	0.0611	122	0.0602	120	53-141	
Benzene	ND	0.0500	0.0567	113	0.0543	109	66-135	
Trichloroethene	ND	0.0500	0.0546	109	0.0559	112	69-130	
Toluene	ND	0.0500	0.0580	116	0.0596	119	72-127	
Chlorobenzene	ND	0.0500	0.0590	118	0.0594	119	68-134	

	RPD	RPD Limit	Flags
1,1-Dichloroethene	2	11	
Benzene	4	11	
Trichloroethene	2	13	
Toluene	3	11	
Chlorobenzene	1	12	

Date of Report: March 15, 2004
Samples Submitted: March 5, 2004
Laboratory Reference: 0403-046
Project: 21-1-09948-001

% MOISTURE

Date Analyzed: 3-9-04

Client ID	Lab ID	% Moisture
SW3-S2	03-046-01	10
SW3-S1	03-046-02	12

OnSite
Environmental Inc.

Data Qualifiers and Abbreviations

A - Due to a high sample concentration, the amount spiked is insufficient for meaningful MS/MSD recovery data.

B - The analyte indicated was also found in the blank sample.

C - The duplicate RPD is outside control limits due to high result variability when analyte concentrations are within five times the quantitation limit.

E - The value reported exceeds the quantitation range and is an estimate.

F - Surrogate recovery data is not available due to the high concentration of coeluting target compounds.

G - Insufficient sample quantity for duplicate analysis.

H - The analyte indicated is a common laboratory solvent and may have been introduced during sample preparation, and be impacting the sample result.

I - Compound recovery is outside of the control limits.

J - The value reported was below the practical quantitation limit. The value is an estimate.

K - Sample duplicate RPD is outside control limits due to sample inhomogeneity. The sample was re-extracted and re-analyzed with similar results.

L - The RPD is outside of the control limits.

M - Hydrocarbons in the gasoline range (toluene-napthalene) are present in the sample.

O - Hydrocarbons outside the defined gasoline range are present in the sample.

P - The RPD of the detected concentrations between the two columns is greater than 40.

Q - Surrogate recovery is outside of the control limits.

S - Surrogate recovery data is not available due to the necessary dilution of the sample.

T - The sample chromatogram is not similar to a typical ___________.

U - The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

V - Matrix Spike/Matrix Spike Duplicate recoveries are outside control limits due to matrix effects.

W - Matrix Spike/Matrix Spike Duplicate RPD are outside control limits due to matrix effects.

X - Sample extract treated with a silica gel cleanup procedure.

Y - Sample extract treated with an acid cleanup procedure.

Z - The chromatogram is similar to mineral spirits.

ND - Not Detected at PQL
PQL - Practical Quantitation Limit
RPD - Relative Percent Difference

03-046

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

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Richland, WA 99352
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CHAIN-OF-CUSTODY RECORD

Page 1 of 1
Laboratory OnSite
Attn: D Baumeister

Analysis Parameters/Sample Container Description (include preservative if used)

Sample Identity	Lab No.	Time	Date Sampled	Comp.	Grab	NWTPH-Gx	VOCs (8260)				Dry Wt	Total Number of Containers	Remarks/Matrix
SW3-S2	1		3/2/04		X	X	X				X	2	Soil
SW3-S1	2		↓		X	⊗	⊗				X	1	~~please hold (soil)~~
SW3-S3	3		↓		X							1	please hold (soil)

Project Information	
Project Number:	21-1-09948-001
Project Name:	Bremerton Access
Contact:	Scott Gaulke
Ongoing Project?	Yes ☒ No ☐
Sampler:	Scott Pauling

Sample Receipt	
Total Number of Containers	1
COC Seals/Intact? Y/N/NA	
Received Good Cond./Cold	
Delivery Method: (attach shipping bill, if any)	

Instructions

Requested Turnaround Time: standard

Special Instructions: ⊗ per Jennie H. by telephone WH 3/5/04

	Relinquished By: 1.	Relinquished By: 2.	Relinquished By: 3.
Signature:	Jennie Hardwick		
Time:	4:05		
Printed Name:	Jennie Hardwick		
Date:	3/4/04		
Company:	Shannon & Wilson		

	Received By: 1.	Received By: 2.	Received By: 3.
Signature:	[illegible]		
Time:	[illegible]		
Printed Name:	[illegible]		
Date:	3/5/04		
Company:	OnSite Env.		

Distribution: White - w/shipment - returned to Shannon & Wilson w/ laboratory report
Yellow - w/shipment - for consignee files
Pink - Shannon & Wilson - Job File

F-19-91/UR

No.

OnSite
Environmental Inc.
Analytical Testing and Mobile Laboratory Services

March 17, 2004

Scott Gaulke
Shannon & Wilson, Inc.
400 N 34th Street, Suite 100
Seattle, WA 98103

Re: Analytical Data for Project 21-1-09948-002
Laboratory Reference No. 0403-065

Dear Scott:

Enclosed are the analytical results and associated quality control data for samples submitted on March 8, 2004.

The standard policy of OnSite Environmental Inc. is to store your samples for 30 days from the date of receipt. If you require longer storage, please contact the laboratory.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning the data, or need additional information, please feel free to call me.

Sincerely,

David Baumeister
Project Manager

Enclosures

14648 NE 95th Street, Redmond, WA 98052 • (425) 883-3881 • Fax (425) 885-4603

Date of Report: March 17, 2004
Samples Submitted: March 8, 2004
Laboratory Reference: 0403-065
Project: 21-1-09948-002

Case Narrative

Samples were collected on March 5, 2004 and received by the laboratory on March 8, 2004. They were maintained at the laboratory at a temperature of 2°C to 6°C.

General QA/QC issues associated with the analytical data enclosed in this laboratory report will be indicated with a reference to a comment or explanation on the Data Qualifier page. More complex and involved QA/QC issues will be discussed in detail below.

<u>Volatiles EPA 8260B Analysis</u>

The 8-oz. containers provided for samples S-1 @ 2.5-4 and S-2 @ 5-7.5 contained headspace.

Any other QA/QC issues associated with this extraction and analysis will be indicated with a footnote reference and discussed in detail on the Data Qualifier page.

Date of Report: March 17, 2004
Samples Submitted: March 8, 2004
Laboratory Reference: 0403-065
Project: 21-1-09948-002

VOLATILES by EPA 8260B
Page 1 of 2

Date Extracted:	3-9-04
Date Analyzed:	3-9-04
Matrix:	Soil
Units:	mg/kg (ppm)
Lab ID:	03-065-01
Client ID:	**S-1@2.5-4**

Compound	**Results**	**Flags**	**PQL**
Dichlorodifluoromethane	ND		0.0011
Chloromethane	ND		0.0011
Vinyl Chloride	ND		0.0011
Bromomethane	ND		0.0011
Chloroethane	ND		0.0011
Trichlorofluoromethane	ND		0.0011
1,1-Dichloroethene	ND		0.0011
Acetone	ND		0.0055
Iodomethane	ND		0.0055
Carbon Disulfide	ND		0.0011
Methylene Chloride	ND		0.0055
(trans) 1,2-Dichloroethene	ND		0.0011
Methyl t-Butyl Ether	ND		0.0011
1,1-Dichloroethane	ND		0.0011
Vinyl Acetate	ND		0.0055
2,2-Dichloropropane	ND		0.0011
(cis) 1,2-Dichloroethene	ND		0.0011
2-Butanone	ND		0.0055
Bromochloromethane	ND		0.0011
Chloroform	ND		0.0011
1,1,1-Trichloroethane	ND		0.0011
Carbon Tetrachloride	ND		0.0011
1,1-Dichloropropene	ND		0.0011
Benzene	ND		0.0011
1,2-Dichloroethane	ND		0.0011
Trichloroethene	ND		0.0011
1,2-Dichloropropane	ND		0.0011
Dibromomethane	ND		0.0011
Bromodichloromethane	ND		0.0011
2-Chloroethyl Vinyl Ether	ND		0.0055
(cis) 1,3-Dichloropropene	ND		0.0011
Methyl Isobutyl Ketone	ND		0.0055
Toluene	ND		0.0011
(trans) 1,3-Dichloropropene	ND		0.0011

Date of Report: March 17, 2004
Samples Submitted: March 8, 2004
Laboratory Reference: 0403-065
Project: 21-1-09948-002

VOLATILES by EPA 8260B
Page 2 of 2

Lab ID: 03-065-01
Client ID: S-1@2.5-4

Compound	Results	Flags	PQL
1,1,2-Trichloroethane	ND		0.0011
Tetrachloroethene	ND		0.0011
1,3-Dichloropropane	ND		0.0011
2-Hexanone	ND		0.0055
Dibromochloromethane	ND		0.0011
1,2-Dibromoethane	ND		0.0011
Chlorobenzene	ND		0.0011
1,1,1,2-Tetrachloroethane	ND		0.0011
Ethylbenzene	ND		0.0011
m,p-Xylene	ND		0.0022
o-Xylene	ND		0.0011
Styrene	ND		0.0011
Bromoform	ND		0.0011
Isopropylbenzene	ND		0.0011
Bromobenzene	ND		0.0011
1,1,2,2-Tetrachloroethane	ND		0.0011
1,2,3-Trichloropropane	ND		0.0011
n-Propylbenzene	ND		0.0011
2-Chlorotoluene	ND		0.0011
4-Chlorotoluene	ND		0.0011
1,3,5-Trimethylbenzene	ND		0.0011
tert-Butylbenzene	ND		0.0011
1,2,4-Trimethylbenzene	ND		0.0011
sec-Butylbenzene	ND		0.0011
1,3-Dichlorobenzene	ND		0.0011
p-Isopropyltoluene	ND		0.0011
1,4-Dichlorobenzene	ND		0.0011
1,2-Dichlorobenzene	ND		0.0011
n-Butylbenzene	ND		0.0011
1,2-Dibromo-3-chloropropane	ND		0.0055
1,2,4-Trichlorobenzene	ND		0.0011
Hexachlorobutadiene	ND		0.0055
Naphthalene	ND		0.0011
1,2,3-Trichlorobenzene	ND		0.0011

Surrogate	Percent Recovery	Control Limits
Dibromofluoromethane	94	71-126
Toluene, d8	98	73-130
4-Bromofluorobenzene	108	70-130

Date of Report: March 17, 2004
Samples Submitted: March 8, 2004
Laboratory Reference: 0403-065
Project: 21-1-09948-002

VOLATILES by EPA 8260B
Page 1 of 2

Date Extracted:	3-9-04
Date Analyzed:	3-9-04
Matrix:	Soil
Units:	mg/kg (ppm)
Lab ID:	03-065-02
Client ID:	**S-2@5-7.5**

Compound	Results	Flags	PQL
Dichlorodifluoromethane	ND		0.0011
Chloromethane	ND		0.0011
Vinyl Chloride	ND		0.0011
Bromomethane	ND		0.0011
Chloroethane	ND		0.0011
Trichlorofluoromethane	ND		0.0011
1,1-Dichloroethene	ND		0.0011
Acetone	ND		0.0053
Iodomethane	ND		0.0053
Carbon Disulfide	ND		0.0011
Methylene Chloride	ND		0.0053
(trans) 1,2-Dichloroethene	ND		0.0011
Methyl t-Butyl Ether	ND		0.0011
1,1-Dichloroethane	ND		0.0011
Vinyl Acetate	ND		0.0053
2,2-Dichloropropane	ND		0.0011
(cis) 1,2-Dichloroethene	ND		0.0011
2-Butanone	ND		0.0053
Bromochloromethane	ND		0.0011
Chloroform	ND		0.0011
1,1,1-Trichloroethane	ND		0.0011
Carbon Tetrachloride	ND		0.0011
1,1-Dichloropropene	ND		0.0011
Benzene	ND		0.0011
1,2-Dichloroethane	ND		0.0011
Trichloroethene	ND		0.0011
1,2-Dichloropropane	ND		0.0011
Dibromomethane	ND		0.0011
Bromodichloromethane	ND		0.0011
2-Chloroethyl Vinyl Ether	ND		0.0053
(cis) 1,3-Dichloropropene	ND		0.0011
Methyl Isobutyl Ketone	ND		0.0053
Toluene	ND		0.0011
(trans) 1,3-Dichloropropene	ND		0.0011

Date of Report: March 17, 2004
Samples Submitted: March 8, 2004
Laboratory Reference: 0403-065
Project: 21-1-09948-002

VOLATILES by EPA 8260B

Lab ID: 03-065-02
Client ID: S-2@5-7.5

Compound	Results	Flags	PQL
1,1,2-Trichloroethane	ND		0.0011
Tetrachloroethene	ND		0.0011
1,3-Dichloropropane	ND		0.0011
2-Hexanone	ND		0.0053
Dibromochloromethane	ND		0.0011
1,2-Dibromoethane	ND		0.0011
Chlorobenzene	ND		0.0011
1,1,1,2-Tetrachloroethane	ND		0.0011
Ethylbenzene	ND		0.0011
m,p-Xylene	ND		0.0021
o-Xylene	ND		0.0011
Styrene	ND		0.0011
Bromoform	ND		0.0011
Isopropylbenzene	ND		0.0011
Bromobenzene	ND		0.0011
1,1,2,2-Tetrachloroethane	ND		0.0011
1,2,3-Trichloropropane	ND		0.0011
n-Propylbenzene	ND		0.0011
2-Chlorotoluene	ND		0.0011
4-Chlorotoluene	ND		0.0011
1,3,5-Trimethylbenzene	ND		0.0011
tert-Butylbenzene	ND		0.0011
1,2,4-Trimethylbenzene	ND		0.0011
sec-Butylbenzene	ND		0.0011
1,3-Dichlorobenzene	ND		0.0011
p-Isopropyltoluene	ND		0.0011
1,4-Dichlorobenzene	ND		0.0011
1,2-Dichlorobenzene	ND		0.0011
n-Butylbenzene	ND		0.0011
1,2-Dibromo-3-chloropropane	ND		0.0053
1,2,4-Trichlorobenzene	ND		0.0011
Hexachlorobutadiene	ND		0.0053
Naphthalene	ND		0.0011
1,2,3-Trichlorobenzene	ND		0.0011

Surrogate	Percent Recovery	Control Limits
Dibromofluoromethane	76	71-126
Toluene, d8	86	73-130
4-Bromofluorobenzene	81	70-130

Date of Report: March 17, 2004
Samples Submitted: March 8, 2004
Laboratory Reference: 0403-065
Project: 21-1-09948-002

VOLATILES by EPA 8260B
METHOD BLANK QUALITY CONTROL

Date Extracted: 3-9-04
Date Analyzed: 3-9-04

Matrix: Soil
Units: mg/kg (ppm)

Lab ID: MB0309S1

Compound	Results	Flags	PQL
Dichlorodifluoromethane	ND		0.0010
Chloromethane	ND		0.0010
Vinyl Chloride	ND		0.0010
Bromomethane	ND		0.0010
Chloroethane	ND		0.0010
Trichlorofluoromethane	ND		0.0010
1,1-Dichloroethene	ND		0.0010
Acetone	ND		0.0050
Iodomethane	ND		0.0050
Carbon Disulfide	ND		0.0010
Methylene Chloride	ND		0.0050
(trans) 1,2-Dichloroethene	ND		0.0010
Methyl t-Butyl Ether	ND		0.0010
1,1-Dichloroethane	ND		0.0010
Vinyl Acetate	ND		0.0050
2,2-Dichloropropane	ND		0.0010
(cis) 1,2-Dichloroethene	ND		0.0010
2-Butanone	ND		0.0050
Bromochloromethane	ND		0.0010
Chloroform	ND		0.0010
1,1,1-Trichloroethane	ND		0.0010
Carbon Tetrachloride	ND		0.0010
1,1-Dichloropropene	ND		0.0010
Benzene	ND		0.0010
1,2-Dichloroethane	ND		0.0010
Trichloroethene	ND		0.0010
1,2-Dichloropropane	ND		0.0010
Dibromomethane	ND		0.0010
Bromodichloromethane	ND		0.0010
2-Chloroethyl Vinyl Ether	ND		0.0050
(cis) 1,3-Dichloropropene	ND		0.0010
Methyl Isobutyl Ketone	ND		0.0050
Toluene	ND		0.0010
(trans) 1,3-Dichloropropene	ND		0.0010

Date of Report: March 17, 2004
Samples Submitted: March 8, 2004
Laboratory Reference: 0403-065
Project: 21-1-09948-002

VOLATILES by EPA 8260B
METHOD BLANK QUALITY CONTROL
Page 2 of 2

Lab ID: MB0309S1

Compound	Results	Flags	PQL
1,1,2-Trichloroethane	ND		0.0010
Tetrachloroethene	ND		0.0010
1,3-Dichloropropane	ND		0.0010
2-Hexanone	ND		0.0050
Dibromochloromethane	ND		0.0010
1,2-Dibromoethane	ND		0.0010
Chlorobenzene	ND		0.0010
1,1,1,2-Tetrachloroethane	ND		0.0010
Ethylbenzene	ND		0.0010
m,p-Xylene	ND		0.0020
o-Xylene	ND		0.0010
Styrene	ND		0.0010
Bromoform	ND		0.0010
Isopropylbenzene	ND		0.0010
Bromobenzene	ND		0.0010
1,1,2,2-Tetrachloroethane	ND		0.0010
1,2,3-Trichloropropane	ND		0.0010
n-Propylbenzene	ND		0.0010
2-Chlorotoluene	ND		0.0010
4-Chlorotoluene	ND		0.0010
1,3,5-Trimethylbenzene	ND		0.0010
tert-Butylbenzene	ND		0.0010
1,2,4-Trimethylbenzene	ND		0.0010
sec-Butylbenzene	ND		0.0010
1,3-Dichlorobenzene	ND		0.0010
p-Isopropyltoluene	ND		0.0010
1,4-Dichlorobenzene	ND		0.0010
1,2-Dichlorobenzene	ND		0.0010
n-Butylbenzene	ND		0.0010
1,2-Dibromo-3-chloropropane	ND		0.0050
1,2,4-Trichlorobenzene	ND		0.0010
Hexachlorobutadiene	ND		0.0050
Naphthalene	ND		0.0010
1,2,3-Trichlorobenzene	ND		0.0010

Surrogate	Percent Recovery	Control Limits
Dibromofluoromethane	88	71-126
Toluene, d8	89	73-130
4-Bromofluorobenzene	84	70-130

Date of Report: March 17, 2004
Samples Submitted: March 8, 2004
Laboratory Reference: 0403-065
Project: 21-1-09948-002

VOLATILES by EPA 8260B
MS/MSD QUALITY CONTROL

Date Extracted: 3-9-04
Date Analyzed: 3-9-04

Matrix: Soil
Units: mg/kg (ppm)

Lab ID: 03-053-06

Compound	Sample Amount	Spike Amount	MS	Percent Recovery	MSD	Percent Recovery	Recovery Limits
1,1-Dichloroethene	ND	0.0500	0.0611	122	0.0602	120	53-141
Benzene	ND	0.0500	0.0567	113	0.0543	109	66-135
Trichloroethene	ND	0.0500	0.0546	109	0.0559	112	69-130
Toluene	ND	0.0500	0.0580	116	0.0596	119	72-127
Chlorobenzene	ND	0.0500	0.0590	118	0.0594	119	68-134

	RPD	RPD Limit	Flags
1,1-Dichloroethene	2	11	
Benzene	4	11	
Trichloroethene	2	13	
Toluene	3	11	
Chlorobenzene	1	12	

Date of Report: March 17, 2004
Samples Submitted: March 8, 2004
Laboratory Reference: 0403-065
Project: 21-1-09948-002

NWTPH-Gx
METHOD BLANK QUALITY CONTROL

Date Extracted: 3-12-04

Date Analyzed: 3-12-04

Matrix: Soil
Units: mg/kg (ppm)

Lab ID: MB0312S1

	Result	Flags	PQL
TPH-Gas	ND		5.0
Surrogate Recovery:			
Fluorobenzene	96%		

Date of Report: March 17, 2004
Samples Submitted: March 8, 2004
Laboratory Reference: 0403-065
Project: 21-1-09948-002

NWTPH-Gx
DUPLICATE QUALITY CONTROL

Date Extracted: 3-12-04
Date Analyzed: 3-12-04

Matrix: Soil
Units: mg/kg (ppm)

Lab ID:	03-065-02 **Original**	03-065-02 **Duplicate**	**RPD**	**Flags**
TPH-Gas	5.65	6.15	9	
Surrogate Recovery:				
Fluorobenzene	90%	93%		

Date of Report: March 17, 2004
Samples Submitted: March 8, 2004
Laboratory Reference: 0403-065
Project: 21-1-09948-002

% MOISTURE

Date Analyzed: 3-9-04

Client ID	Lab ID	% Moisture
S-1@2.5-4	03-065-01	9
S-2@5-7.5	03-065-02	6

OnSite Environmental Inc.

Data Qualifiers and Abbreviations

A - Due to a high sample concentration, the amount spiked is insufficient for meaningful MS/MSD recovery data.

B - The analyte indicated was also found in the blank sample.

C - The duplicate RPD is outside control limits due to high result variability when analyte concentrations are within five times the quantitation limit.

E - The value reported exceeds the quantitation range and is an estimate.

F - Surrogate recovery data is not available due to the high concentration of coeluting target compounds.

G - Insufficient sample quantity for duplicate analysis.

H - The analyte indicated is a common laboratory solvent and may have been introduced during sample preparation, and be impacting the sample result.

I - Compound recovery is outside of the control limits.

J - The value reported was below the practical quantitation limit. The value is an estimate.

K - Sample duplicate RPD is outside control limits due to sample inhomogeneity. The sample was re-extracted and re-analyzed with similar results.

L - The RPD is outside of the control limits.

M - Hydrocarbons in the gasoline range (toluene-napthalene) are present in the sample.

O - Hydrocarbons outside the defined gasoline range are present in the sample.

P - The RPD of the detected concentrations between the two columns is greater than 40.

Q - Surrogate recovery is outside of the control limits.

S - Surrogate recovery data is not available due to the necessary dilution of the sample.

T - The sample chromatogram is not similar to a typical ___________.

U - The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

V - Matrix Spike/Matrix Spike Duplicate recoveries are outside control limits due to matrix effects.

W - Matrix Spike/Matrix Spike Duplicate RPD are outside control limits due to matrix effects.

X - Sample extract treated with a silica gel cleanup procedure.

Y - Sample extract treated with an acid cleanup procedure.

Z -

ND - Not Detected at PQL
PQL - Practical Quantitation Limit
RPD - Relative Percent Difference

03-065

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

400 N. 34th Street, Suite 100
Seattle, WA 98103
(206) 632-8020
(206) 695-6777 Fax

11500 Olive Blvd., Suite 276
St. Louis, MO 63141
(314) 872-8170
(314) 872-8176 Fax

2055 Hill Road
Fairbanks, AK 99709
(907) 479-0600
(907) 479-5691 Fax

5430 Fairbanks Street, Suite 3
Anchorage, AK 99518
(907) 561-2120
(907) 561-4483 Fax

303 Wellsian Way
Richland, WA 99352
(509) 946-6309
(509) 946-6580 Fax

CHAIN-OF-CUSTODY RECORD

Laboratory: OnSite
Attn:

Analysis Parameters/Sample Container Description
(include preservative if used)

Sample Identity	Lab No.	Time	Date Sampled	Comp.	Grab	VOCs	NWTPH-Gx			Dry Wt		Total Number of Containers	Remarks/Matrix
S-1 @ 2.5-4	1		3/5/04		X	X	X			X		1	Soil
S-2 @ 5-7.5	2		3/5/04		X	X	X			X		1	Soil

Project Information	Sample Receipt	
Project Number: 21-1-09948-007	Total Number of Containers	
Project Name: Bremerton	COC Seals/Intact? Y/N/NA	
Contact: Scott Gaulke	Received Good Cond./Cold	
Ongoing Project? Yes ☒ No ☐	Delivery Method:	
Sampler: SMP	(attach shipping bill, if any)	

Instructions

Requested Turnaround Time: standard

Special Instructions:

Relinquished By: 1.	Relinquished By: 2.	Relinquished By: 3.
Signature: [signature] Time: 10:35	Signature: Time:	Signature: Time:
Printed Name: Jennie Hardwick Date: 3/8/04	Printed Name: Date:	Printed Name: Date:
Company: Shannon & Wilson	Company:	Company:

Received By: 1.	Received By: 2.	Received By: 3.
Signature: [signature] Time: 13:40	Signature: Time:	Signature: Time:
Printed Name: Kelley Wilf Date: 3/8/04	Printed Name: Date:	Printed Name: Date:
Company:	Company:	Company:

Distribution: White - w/shipment - returned to Shannon & Wilson w/ laboratory report
Yellow - w/shipment - for consignee files
Pink - Shannon & Wilson - Job File

F-19-91/UR

No.

OnSite Environmental Inc.
Analytical Testing and Mobile Laboratory Services

April 9, 2004

Scott Gaulke
Shannon & Wilson, Inc.
400 N 34th Street, Suite 100
Seattle, WA 98103

Re: Analytical Data for Project 21-1-09948-002
Laboratory Reference No. 0404-013

Dear Scott:

Enclosed are the analytical results and associated quality control data for samples submitted on April 2, 2004.

The standard policy of OnSite Environmental Inc. is to store your samples for 30 days from the date of receipt. If you require longer storage, please contact the laboratory.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning the data, or need additional information, please feel free to call me.

Sincerely,

David Baumeister
Project Manager

Enclosures

14648 NE 95th Street, Redmond, WA 98052 • (425) 883-3881 • Fax (425) 885-4603

Date of Report: April 9, 2004
Samples Submitted: April 2, 2004
Laboratory Reference: 0404-013
Project: 21-1-09948-002

Case Narrative

Samples were collected on March 31, 2004 and received by the laboratory on April 2, 2004. They were maintained at the laboratory at a temperature of 2°C to 6°C.

General QA/QC issues associated with the analytical data enclosed in this laboratory report will be indicated with a reference to a comment or explanation on the Data Qualifier page. More complex and involved QA/QC issues will be discussed in detail below.

Date of Report: April 9, 2004
Samples Submitted: April 2, 2004
Laboratory Reference: 0404-013
Project: 21-1-09948-002

NWTPH-Gx/BTEX

Date Extracted: 4-6-04
Date Analyzed: 4-6-04

Matrix: Water
Units: ug/L (ppb)

Client ID:	**SW3-033104**			**SW4-033104**		
Lab ID:	04-013-01			04-013-02		
	Result	Flags	PQL	**Result**	Flags	PQL
Benzene	**ND**		1.0	**ND**		1.0
Toluene	**ND**		1.0	**ND**		1.0
Ethyl Benzene	**ND**		1.0	**ND**		1.0
m,p-Xylene	**ND**		1.0	**ND**		1.0
o-Xylene	**ND**		1.0	**ND**		1.0
TPH-Gas	**ND**		100	**ND**		100
Surrogate Recovery:						
Fluorobenzene	94%			90%		

Date of Report: April 9, 2004
Samples Submitted: April 2, 2004
Laboratory Reference: 0404-013
Project: 21-1-09948-002

NWTPH-Gx/BTEX
METHOD BLANK QUALITY CONTROL

Date Extracted: 4-6-04
Date Analyzed: 4-6-04

Matrix: Water
Units: ug/L (ppb)

Lab ID: MB0406W1

	Result	Flags	PQL
Benzene	ND		1.0
Toluene	ND		1.0
Ethyl Benzene	ND		1.0
m,p-Xylene	ND		1.0
o-Xylene	ND		1.0
TPH-Gas	ND		100

Surrogate Recovery:
Fluorobenzene 89%

Date of Report: April 9, 2004
Samples Submitted: April 2, 2004
Laboratory Reference: 0404-013
Project: 21-1-09948-002

NWTPH-Gx/BTEX
DUPLICATE QUALITY CONTROL

Date Extracted: 4-6-04
Date Analyzed: 4-6-04

Matrix: Water
Units: ug/L (ppb)

Lab ID:	04-013-02 **Original**	04-013-02 **Duplicate**	**RPD**	**Flags**
Benzene	**ND**	**ND**	NA	
Toluene	**ND**	**ND**	NA	
Ethyl Benzene	**ND**	**ND**	NA	
m,p-Xylene	**ND**	**ND**	NA	
o-Xylene	**ND**	**ND**	NA	
TPH-Gas	**ND**	**ND**	NA	
Surrogate Recovery:				
Fluorobenzene	90%	89%		

Date of Report: April 9, 2004
Samples Submitted: April 2, 2004
Laboratory Reference: 0404-013
Project: 21-1-09948-002

NWTPH-Gx/BTEX
MS/MSD QUALITY CONTROL

Date Extracted: 4-6-04
Date Analyzed: 4-6-04

Matrix: Water
Units: ug/L (ppb)

Spike Level: 50.0 ppb

Lab ID:	04-013-02 **MS**	Percent Recovery	04-013-02 **MSD**	Percent Recovery	**RPD**	**Flags**
Benzene	**48.1**	**96**	**47.5**	**95**	**1**	
Toluene	**49.7**	**99**	**49.0**	**98**	**1**	
Ethyl Benzene	**50.0**	**100**	**49.3**	**99**	**1**	
m,p-Xylene	**49.9**	**100**	**49.3**	**99**	**1**	
o-Xylene	**50.2**	**100**	**49.4**	**99**	**2**	

Surrogate Recovery:

Fluorobenzene	95%	101%

OnSite
Environmental Inc.

Data Qualifiers and Abbreviations

A - Due to a high sample concentration, the amount spiked is insufficient for meaningful MS/MSD recovery data.

B - The analyte indicated was also found in the blank sample.

C - The duplicate RPD is outside control limits due to high result variability when analyte concentrations are within five times the quantitation limit.

E - The value reported exceeds the quantitation range and is an estimate.

F - Surrogate recovery data is not available due to the high concentration of coeluting target compounds.

G - Insufficient sample quantity for duplicate analysis.

H - The analyte indicated is a common laboratory solvent and may have been introduced during sample preparation, and be impacting the sample result.

I - Compound recovery is outside of the control limits.

J - The value reported was below the practical quantitation limit. The value is an estimate.

K - Sample duplicate RPD is outside control limits due to sample inhomogeneity. The sample was re-extracted and re-analyzed with similar results.

L - The RPD is outside of the control limits.

M - Hydrocarbons in the gasoline range (toluene-napthalene) are present in the sample.

O - Hydrocarbons outside the defined gasoline range are present in the sample.

P - The RPD of the detected concentrations between the two columns is greater than 40.

Q - Surrogate recovery is outside of the control limits.

S - Surrogate recovery data is not available due to the necessary dilution of the sample.

T - The sample chromatogram is not similar to a typical ____________.

U - The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

V - Matrix Spike/Matrix Spike Duplicate recoveries are outside control limits due to matrix effects.

W - Matrix Spike/Matrix Spike Duplicate RPD are outside control limits due to matrix effects.

X - Sample extract treated with a silica gel cleanup procedure.

Y - Sample extract treated with an acid cleanup procedure.

Z -

ND - Not Detected at PQL
PQL - Practical Quantitation Limit
RPD - Relative Percent Difference

304-013

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

CHAIN-OF-CUSTODY RECORD

Page 1 of 1
Laboratory OnSite
Attn:

400 N. 34th Street, Suite 100, Seattle, WA 98103, (206) 632-8020
2043 Westport Center Drive, St. Louis, MO 63146-3564, (314) 392-0050
303 Wellsian Way, Richland, WA 99352, (509) 946-6309
2055 Hill Road, Fairbanks, AK 99709, (907) 479-0600
5430 Fairbanks Street, Suite 3, Anchorage, AK 99518, (907) 561-2120
2255 S.W. Canyon Road, Portland, OR 97201-2498, (503) 223-6147
1200 17th Street, Suite 1024, Denver, Co 80202, (303) 825-3800

Analysis Parameters/Sample Container Description (include preservative if used)

Sample Identity	Lab No.	Time	Date Sampled	Comp.	Grab	NWTPH-G/BTEX						Total Number of Containers	Remarks/Matrix
SW3-033104	1	1100	3/31/04		X	X						4	H_2O - 4 VOAs
SW4-033104	2	0915	3/31/04		X	X						4	↓

Project Information	
Project Number: 21-1-09948-002	
Project Name: Access Improve...	
Contact: Scott Gaulke	
Ongoing Project? Yes ☐ No ☐	
Sampler: JCD	

Sample Receipt	
Total Number of Containers	
COC Seals/Intact? Y/N/NA	
Received Good Cond./Cold	
Delivery Method: (attach shipping bill, if any)	

Instructions
Requested Turnaround Time: Standard
Special Instructions:

Relinquished By: 1.	Relinquished By: 2.	Relinquished By: 3.
Signature: [signature] Time: 1008	Signature: [signature] Time: 1430	Signature: Time:
Printed Name: John Deeds Date: 4/1/04	Printed Name: AGNES TIRAO Date: 4/1/04	Printed Name: Date:
Company: S+W	Company: S+W	Company:

Received By: 1.	Received By: 2.	Received By: 3.
Signature: [signature] Time: 1008	Signature: [signature] Time: 710	Signature: Time:
Printed Name: AGNES TIRAO Date: 4/1/2004	Printed Name: Blair Goodrich Date: 4/2/04	Printed Name: Date:
Company: S+W	Company: OnSite Env.	Company:

Distribution: White - w/shipment - returned to Shannon & Wilson w/ laboratory report
Yellow - w/shipment - for consignee files
Pink - Shannon & Wilson - Job File

F-19-91/UR

No.

Emerald Services Inc.
7343 EAST MARGINAL WAY SOUTH
SEATTLE, WASHINGTON 98108
(206) 832-3000
FAX: (206) 832-3030
24 HOUR EMERGENCY PHONE: 1-800-424-9300

35345

BILL OF LADING AND GALLONAGE TICKET

SHIPPER/GENERATOR Bremerton Public Wor	CONTACT JOHN	JOB # 30-59021
ADDRESS 3027 OLYMPUS DRIVE	PHONE# 930-8710	LOAD #
CITY, STATE, ZIP BREMERTON WA		DATE
CARRIER ESI	PHONE# 832-3000	DOCUMENT #
CONSIGNEE ESP	CONTACT Bill	TRUCK #
ADDRESS 1500 AIRPORT WAY S	PHONE# 832-3090	PRODUCT TYPE
CITY, STATE, ZIP SEATTLE WA		EST. GALLONS

HM	ITEM #	U.S. DOT DESCRIPTION	#	TYPE	QTY.
	A	NON-REGULATED SOIL	6	DM	
	B	NON-REGULATED WATER	2	DM	
	C				
	D				

A. WPQ # G004706 DISP. CODE: NLS
B. WPQ # G00501 DISP. CODE: WTP-A
C. WPQ # ______ DISP. CODE: ______
D. WPQ # ______ DISP. CODE: ______

DISPOSAL

DUMP DELAY TIME ______

WASH OUT: YES ( ) NO ( ) TIME IN ______ TIME OUT ______

E. WATER ______ GALLONS LOCATION ______ TEST ______ DISP. CODE ______

F. SOLIDS ______ GALLONS LOCATION ______ TEST ______ DISP. CODE ______

______ % SUSPENDED SOLIDS BY CENTRIFUGE + ______ GALS SEDIMENT

G. OIL/DIESEL/GAS ______ GALLONS LOCATION ______ TEST ______ DISP. CODE ______

HOC'S ______ PCB'S ______ B.S.&W. ______ API ______ LAB: Y / N

Shipper's Certification: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled, and are in all respects in proper condition for transport by highway, vessel and rail according to applicable international and national government regulations and this material is not regulated as a hazardous waste in accordance with WAC 173-303, 40 CFR. Part 261 or 40 CFR Part 761.

X John Deeds — SHIPPER (PRINT NAME) — X [signature] SIGNATURE — DATE: 3/9/06

X ______ CARRIER - DRIVER 1 (PRINT NAME) — X ______ SIGNATURE — DATE: ______

X ______ CARRIER - DRIVER 2 (PRINT NAME) — X ______ SIGNATURE — DATE: ______

X ______ CONSIGNEE (PRINT NAME) — X ______ SIGNATURE — DATE: ______

APPENDIX D

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Attachment to and part of Report 21-1-09948-003

Date: July 21, 2006
To: Mr. Gary Demich
Exeltech Consulting, Inc.

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland